INSTRUCTION MANUAL

FREQUENCY SELECTIVE VOLTMETER

Sierra

MODEL 128A

Serial Numbers 131-205

Stock No. 950000133

112064

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

Serial No. 131 and above

ERRATA SHEET

In SECTION II OPERATION add the following as subparagraph 9 under B. OPERATIONAL CALIBRATION:

9. If the Incremental Tuning Oscillator does not tend to stay in the locked condition, LOCK indicator light goes out, or if it does not return to the locked condition immediately after going out, change the ADJ control, just to the right of the INCREMENTAL LOCK indicator light, until the INCREMENTAL Tuning LOCK indicator light stays on. Several turns may be required. The ADJ control is a 26 turn continuous travel potentiometer which has been factory set at mid-range.

In SECTION III CIRCUIT DESCRIPTION add the following at the end of subparagraph 5 under C. INCREMENTAL TUNING AND FREQUENCY LOCK CIRCUITS:

To provide for any possible change in locking characteristics with passage of time, the LOCK ADJ control, R1 a 26 turn continuous travel potentiometer, located just to the right of the INCREMENTAL LOCK indicator light on the front panel, is provided. The control adjusts a fixed bias on the varactor diode, CR1, in the Second Oscillator circuit to restore the Second Oscillator frequency to the mean of the locking range. Schematically the potentiometer is connected to the Incremental Tuning Oscillator circuit board.

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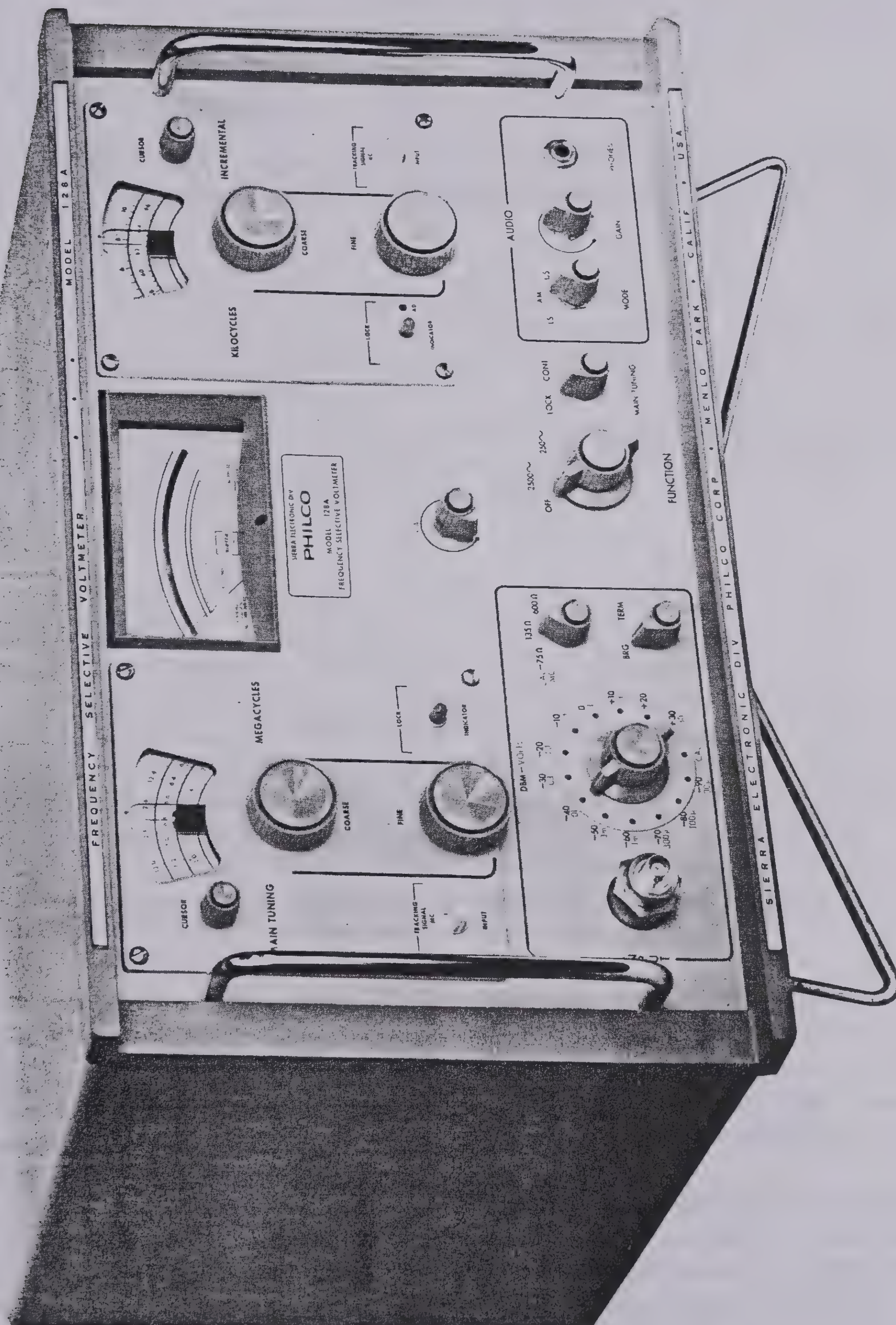


Figure 1-1. Model 128A Frequency Selective Voltmeter

SECTION I
GENERAL

A. PURPOSE

The Model 128A Frequency Selective Voltmeter is designed to measure a wide range of power levels and voltages with a high degree of accuracy over the frequency range of 10 kc to 15.1 mc.

It may be used to measure signal or carrier levels, harmonics, noise, crosstalk, or interfering signals in communications systems or communications receiving and transmitting equipment. It can also be synchronously tuned by a Tracking Signal Generator* when making a frequency run on a transmission line or circuit of a communications system. Either a narrow or wide bandwidth mode of operation is available in the instrument. Since the Voltmeter may be operated from either an ac or battery power source, it is readily adaptable for use in the field, at a communications terminal or in the laboratory.

B. DESCRIPTION

The Model 128A is a fully transistorized instrument employing modular circuit boards for component mounting. To provide adequate shielding for low level signals and stability of operation of the frequency generating sections, four aluminum castings are used to enclose a large part of the instrument circuitry. The castings are internally divided into compartments, each of which contains a circuit board assembly. This construction provides a high degree of isolation between circuits. The remainder of the circuit board assemblies are mounted on the chassis or the front panel. Shielded compartments are also used for these circuits where necessary.

The voltmeter may be tuned either continuously or frequency locked every 100 kc. Frequency lock is indicated by a relay operated panel lamp. Both aural (relay click) and visual (panel lamp) indication of the locked condition are thus furnished. For frequencies intermediate to the 100 kc points an Incremental Oscillator is used. The tuned frequency is the sum of the frequencies indicated by the Main Tuning and Incremental Tuning dials.

Input circuits of the Frequency Selective Voltmeter may be set for either the terminating or bridging mode. The termination mode provides a termination impedance to match either 75, 135 or 600 ohm lines or circuits. In the bridging mode the input impedance is sufficiently high, approximately 100,000 ohms, to insure a low bridging loss. Refer to Block Diagram Figure 1-2 for relationships of the various circuits.

*Sierra Model 351A

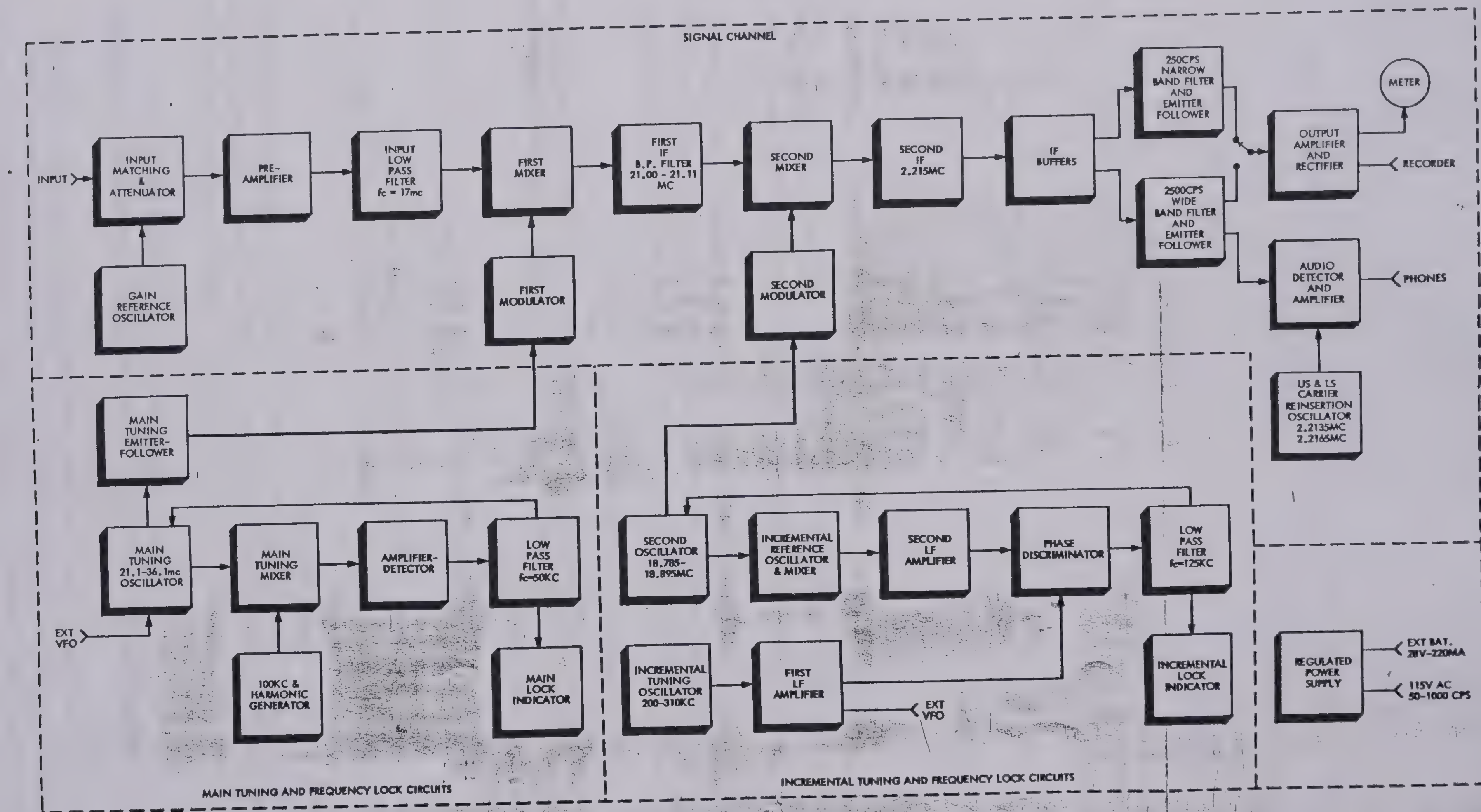


Figure 1-2. Model 128A Block Diagram

The Input Attenuator is adjustable in 10 db steps and is calibrated from -90 dbm to +30 dbm. The Attenuator is also calibrated in volts, the panel scale range being from 30 μ volts to 30 volts. To measure voltage the input must be set to the 600 ohm position.

Operational calibration of the instrument is provided by an internal Gain Reference oscillator. The output of this 1 mc crystal controlled oscillator is highly stabilized.

Bandwidth may be selected with a front panel control. Bandwidths of either 250 cps or 2500 cps are determined by crystal band-pass filters. Audio modulation on the signal may be continuously monitored through the wide band filter, the output of which is permanently connected to the input of the audio amplifier.

Monitoring of single sideband carrier systems is provided for by internal carrier re-insertion oscillators. Either sideband may be selected with a front panel switch.

A recorder output is available with an output of 0-200 μa through a resistance of not more than 1200 ohms.

To provide for synchronous tuning of the Frequency Selective Voltmeter by means of a Tracking Signal Generator, input connectors are mounted on the dial panels of both the Main Tuning Oscillator and the Incremental Tuning Oscillator.

Dial drives of both oscillators have coarse and fine tuning controls. The dial calibrations are on a spiral scale and a cursor index automatically moves to indicate the proper reading point on the dial. This provides a long scale with widely spaced scale divisions.

Both tuning dials are fitted with a cursor adjustment as a front panel control The index on the cursor may be set to the proper point on the dial scale using the internal one megacycle Gain Reference oscillator.

C. SPECIFICATIONS

FREQUENCY RANGE	10 kc to 15.1 mc
Main Tuning	
Locked, in 100 kc steps	0, 100, 200 kc. . 15 mc
Unlocked, continuous	0 to 15.1 mc
Incremental Tuning	
Continuous	- 10 to 100 kc
Minimum Reading Increment	500 cycles
Accuracy, lock system actuated	20 ppm ±300 cycles

AUTOMATIC TRACKING TUNING

Required from external Tracking Signal Generator	
Main Tuning Frequency	21.1 mc to 36.1 mc
Incremental Tuning Frequency	200 kc to 310 kc

INPUT LEVEL RANGE

DBM (75Ω, 135Ω, 600Ω)	-90 to +32 dbm full scale
Minimum Reading Level	- 110 dbm
Voltage range (600Ω position only)	30μv to 30 volts full scale

MEASUREMENT ACCURACY

At reference frequency of 1 mc and 0 dbm level	±0.2 db
Frequency response referred to 1 mc	
In Attenuator Positions -70 db to +30 db	
100 kc to 10 mc	±0.2 db
10 kc to 15 mc	±0.5 db
In Attenuator Positions -90 db to -80 db	
10 kc to 10 mc	±0.5 db
10 kc to 15 mc	±0.7 db
Attenuator Accuracy, Bridging Mode	
At 1 mc	±0.1 db
At 10 mc	±0.2 db
At 15 mc	±0.3 db
Variation in accuracy due to line voltage	
Variation of ±10%	0.1 db
Level Calibration Frequency	1 mc, Crystal Controlled

INPUT IMPEDANCE

Bridging Mode	Unbalanced
Resistance	Greater than 100KΩ
Capacitance	
Attenuator Setting	
-60 db to +30 db	30 pf approximately
-90 db to -70 db	60 pf approximately

Terminating Mode	75Ω, 135Ω, 600Ω
Reflection Coefficient	Less than 5%
SELECTIVITY	
Bandwidths (Switch Selected)	2
Wide (Crystal Filter)	2500 cps (3 db points) 10000 cps (60 db points)
Narrow (Crystal Filter)	250 cps (3 db points) 1000 cps (60 db points)
INTERMEDIATE FREQUENCIES (Dual Conversion)	
First IF	21.0 to 21.11 mc
Second IF	2.215 mc
SPURIOUS RESPONSES	
Image Frequency Rejection (42 to 57 mc)	70 db down
Direct First IF Response (21.0 to 21.11 mc)	70 db down
Direct Second IF Response (2.215 mc)	80 db down
Residual Distortion Attenuation with an increase in Sensitivity of 50 db	Greater than 65 db
AUDIO	
Audio Monitor	Continuous operation independent of bandwidth mode
Detection	
Amplitude Modulation	AM Detector
Single Sideband	Carrier Reinsertion combined AM detector
Output	Phones (600Ω minimum impedance)
Recorder Output	
Load Impedance	No greater than 1200Ω
Output Level (Current)	0 to 200 μa through load impedance
Output Connector	Telephone Jack
TEMPERATURE RANGE	+15°C to +40°C

POWER REQUIREMENT	
Line Power	115 volts AC ±10% 50-1000 cycles
External Battery	28 volts DC 220 ma
OVERALL DIMENSIONS (Cabinet)	
Width	20 inches
Height	12 inches
Depth	14 inches
Rack Mounting (Cabinet Removed)	Standard 19 in. width
WEIGHT (In Cabinet)	50 pounds approximately

ACCESSORIES

A Balanced Probe, Model 128-PA, and an Expanded Scale Meter, Model 128-MA, are available as accessories to the Model 128A Selective Frequency Voltmeter. See the description and specifications of these instruments at the back of this Instruction Manual.

SECTION II
OPERATION

A. CONTROLS AND INDICATORS

The front panel controls and indicators are listed below along with a brief indication of their use and the schematic reference number.

1. MAIN TUNING MEGACYCLES

Control or Indicator	Use	Schem. Ref. No.
COARSE	Coarse Adjustment MAIN TUNING	C1
FINE	Fine Adjustment MAIN TUNING	C1
CURSOR	Index Adjustment MAIN TUNING	
LOCK INDICATOR	Mode Indicator MAIN TUNING	DS1
TRACKING SIGNAL INPUT MC	Input for Synchronous Tuning	J2

2. INPUT

Control or Indicator	Use	Schem. Ref. No.
INPUT	GR Locking Input Connector	J1
DBM-VOLTS	Input Attenuator	S2
CAL - 75Ω - 135Ω - 600Ω	Input Impedance Selector	S4
BRG TERM	Input Mode Selector	S3

3. FUNCTION

Control or Indicator	Use	Schem. Ref. No.
CAL	Adjustment for Operational Calibration	R34
OFF 2500 cps 250 cps	Instrument Power On-Off Bandwidth Selector	S1
LOCK CONT MAIN TUNING	MAIN TUNING Mode Selector	S5

4. INCREMENTAL KILOCYCLES

Control or Indicator	Use	Schem. Ref. No.
COARSE	Coarse Adjustment INCREMENTAL Tuning	C1
FINE	Fine Adjustment INCREMENTAL Tuning	C1
CURSOR	Index Adjustment INCREMENTAL Tuning	
LOCK INDICATOR	Mode Indicator INCREMENTAL Tuning	DS2
TRACKING SIGNAL INPUT KC	Input for Synchronous Tuning	J3

5. AUDIO

Control or Indicator	Use	Schem. Ref. No.
MODE LS AM US	Detector Mode Selector	S6
GAIN	Audio Output Level Adjustment	R39
PHONES	Audio Output	J4

6. READOUT

Control or Indicator	Use	Schem. Ref. No.
Meter	Dbm or Volts	M1
RECORDER	Output for Recorder (on rear of chassis)	J5

B. OPERATIONAL CALIBRATION

Procedure for Operational Calibration sets the overall sensitivity of the voltmeter for all of its ranges. The highly stabilized Gain Reference Oscillator, the output of which is nominally within ±0.1 db under room ambient conditions, is used as the standard. (Level calibration must be carried out at the 1 mc frequency only.) Procedure follows:

1. Set INPUT DBM-VOLTS attenuator to CAL. (Full clockwise rotation.)

2. Set INPUT Impedance selector to CAL-75Ω.

3. Set FUNCTION Bandwidth selector to 250 cps.

4. Place FUNCTION MAIN TUNING Mode selector in LOCK position.

5. Set MAIN TUNING MEGACYCLES dial to 1 mc (LOCKED light will come on to indicated frequency locked condition.)

6. Set INCREMENTAL KILOCYCLES dial to 0 and carefully adjust tuning for maximum meter reading.

7. Adjust FUNCTION CAL control until meter reads 0 dbm.

8. If necessary set the cursor index directly under 0 mark on INCREMENTAL Tuning dial using CURSOR adjustment. If it is desired to set cursor on MAIN TUNING dial, set the dial, in the locked condition at 1 mc, or any harmonic, so that it is half way between the points at which it goes out of lock. With the CURSOR adjustment, set index directly under the 1 mc scale division mark, or at any of the harmonics of 1 mc.

C. OPERATIONAL MEASUREMENTS

1. INPUT DBM-VOLTS Attenuator should be turned full clockwise to +30 dbm, or CAL, before connection is made to line or circuit, as a precautionary measure.

2. Perform Operational Calibration as outlined in B. above.

3. Set INPUT Impedance selector to the impedance of line or circuit to be checked, or to 600Ω if voltage is to be measured.

4. Set INPUT Mode selector to BRG if measurement is to be made across a line or circuit already terminated. Set to TERM if the line must be terminated in its characteristic impedance.

5. If frequency of desired signal is known:

a. Set FUNCTION Bandwidth selector to 2500 cps.

b. Set FUNCTION MAIN TUNING Mode selector to LOCK.

c. Set INPUT DBM-VOLTS Attenuator to approximately the expected signal level.

d. Set INCREMENTAL Tuning dial to 0 kc.

e. Set the MAIN TUNING frequency dial to the nearest 100 kc lock point below the signal frequency.

f. Adjust INCREMENTAL Tuning for maximum meter reading.

g. Adjust Attenuator for a meter reading between -10 and +2 db.

h. Set FUNCTION Bandwidth selector to 250 cps and again adjust INCREMENTAL Tuning for maximum meter reading.

6. If frequency of signal to be measured is not known, or only approximately known:

a. Follow procedure steps a. through d. as given in paragraph 5. above, except that MAIN TUNING Mode selector should be set to CONT.

b. Rotate MAIN TUNING dial until an indication is seen on the meter. If necessary, set attenuator to progressively lower (greater sensitivity) levels and search for signal until a meter indication is obtained. Reduce sensitivity if meter "kick" seems large when passing over signal. A signal 20 db below the attenuator setting may be readily found with careful tuning.

c. Set MAIN TUNING Mode selector to LOCK and follow procedure e. through h. in paragraph 5. above.

7. Readout

a. DBM levels. (Assuming INPUT Impedance selector set to proper line impedance and line properly terminated.) Signal level is the algebraic sum of the attenuator db setting and the meter reading.

Example: Attenuator -20 dbm, Meter -4 dbm.
(-20) + (-4) = -24 dbm

Example: Attenuator -20 dbm, Meter +1 dbm.
(-20) + (+1) = -19 dbm

Example: Attenuator +20 dbm, Meter -4 dbm.
(+20) + (-4) = +16 dbm

b. Voltage Levels. (Assuming INPUT Impedance selector is set to 600Ω.) The meter has two voltage scales, 0-1 and 0-3. The attenuator range settings 100μ, 1m, .01, .1, 1, 10 volts apply to the 0-1 scale. The range settings 30μ, 300μ, 3m, .03, .3, 3, 30 volts apply to the 0-3 scale. Each attenuator range setting refers to the maximum voltage that can be read on the appropriate meter scale.

Example: Attenuator 1m, Meter .8
Read .8 millivolts, or 800 microvolts.

Example: Attenuator .03, Meter 1.5
Read .015 volts

c. Frequency. The frequency to which the voltmeter is tuned is the sum of the MAIN TUNING dial indication in megacycles plus the INCREMENTAL Tuning dial indication in megacycles (kilocycles reading converted to megacycles).

Example: MAIN TUNING 11.3 mc, INCREMENTAL Tuning 34.5 kc.
Frequency = 11.3 mc + .0345 mc = 11.3345 mc

8. Recorder Output

If a record of signal level changes on the line or circuit being monitored is desired, a recording device may be driven from the rear chassis jack marked RECORDER. The recording device will then be in series with the meter, but will not affect the meter reading as long as the recorder input resistance is 1200 ohms or less. Since the meter has a 200 microampere movement, approximately 200 microamperes through the recorder input will correspond to +2 dbm.

SECTION III

CIRCUIT DESCRIPTION

A. SIGNAL CHANNEL

This division of the circuit description includes the circuits in the main signal path through the instrument from input to outputs. In addition, the Carrier Reinsertion oscillators and the Gain Reference oscillator are described. Refer to Schematic Diagram Figure 3-5 and to Block Diagram Figure 1-2.

1. Input Matching and Attenuator Circuits

a. Impedance and Level Adjustment. The proper load termination impedance to match 75Ω, 135Ω, and 600Ω lines may be selected when INPUT Mode selector switch S3 is in the TERM position. The correct line impedance is selected by INPUT Impedance selector switch S4A. S4B-S4C sections of this switch function in either TERM or BRG Input Mode to select the proper level-adjusting network. Level to the preamplifier must be set to compensate for the different voltage levels corresponding to zero dbm across the various line impedances.

b. Attenuator. The input attenuator is a capacitive divider network which functions to keep the input signal level to the preamplifier within the limits required for the full scale range of the output meter. Thirteen attenuator positions in 10 db steps, selected by switch S2A-S2B, cover the range from -90 to +30 dbm. Attenuation is reduced to increase sensitivity for every step except for the -90 dbm position. In this position switch S2C operates a relay in the Output Amplifier circuit which increases the amplifier gain by 10 db to provide -90 dbm full scale sensitivity.

2. Preamplifier

A wide-band well stabilized preamplifier provides an impedance match between the high impedance of the input attenuator and the low impedance of the input filter without sacrificing gain. The amplifier consists of Q1-Q2 connected as a Darlington amplifier while Q3 is common-emitter connected. The emitter circuit of Q3 includes a high frequency adjustment.

3. Input Low-Pass Filter

Attenuation of all frequencies above the range of the instrument is accomplished by a four section low-pass filter. It is essentially flat over the pass-band range and cuts off at about 16 mc. The filter is made adjustable to provide for more precise overall alignment.

4. First Mixer, First Modulator and First IF

Frequency conversion from the signal frequency at the instrument input to the first intermediate frequency of 21.05 mc is carried out in the First Mixer. The signal at the input frequency is applied to the base of the mixer transistor Q1. The output of the Main Tuning Oscillator is applied to the First Modulator. The output of this balanced Modulator is connected across the emitter resistor of Mixer transistor Q1. Since the Modulator output is balanced to ground, the Main Tuning Oscillator frequency does not appear in the output, but the RF impedance of the modulator output varies at the Main Tuning Oscillator frequency rate. This varying impedance, connected across the emitter resistance of the Mixer transistor, causes the gain of Q1 to vary at this rate. The effect is to generate the sum and difference frequencies of the signal and Main Tuning Oscillator frequencies, but to practically eliminate the MAIN TUNING Oscillator frequency. The first IF circuit, which provides the load for the collector of the Mixer amplifer, is tuned to the difference frequency of 21.05 mc and thus only this frequency is amplified. The First IF circuit is a steep skirted band-pass filter with a very flat response over a bandwidth of about 150 kc, centered on 21.05 mc. This bandwidth is necessary in order to accommodate signals 50 kc above and below the center frequency of the first IF stage, as the voltmeter is tuned between the 100 kc lock points with the Incremental Tuning Oscillator. Extreme flatness prevents change in gain over this bandwidth.

5. Second Mixer and Second Modulator

The Second Mixer and Modulator circuits operate in a manner similar to the First Mixer and Modulator. Input to the Second Modulator is from the Second Oscillator. First IF signal and Second Modulator output into the Second Mixer produce the second intermediate frequency of 2.215 mc. The Second Mixer has a single tuned circuit in the collector, tuned to the second intermediate frequency, as does the first stage of the Second IF amplifier to which the output of the Second Mixer is fed.

6. Second IF Amplifier

a. IF Buffer Amplifiers. After passing through the initial stage of the Second IF amplifier, the signal is applied to the two IF Buffer amplifiers. These common-emitter stages not only separate the signal into two parallel channels, but also make it possible to provide the correct source impedance for the two crystal filters connected to their outputs.

b. Crystal Filters. The Crystal Filters, FL1 and FL2, determine the overall selectivity of the Frequency Selective Voltmeter. Both filters are centered on 2.215 mc. The narrow band filter FL2 has a bandwidth of 250 cycles, while the wide-band filter FL1 has a bandwidth of 2500 cycles.

c. Narrow and Wide Band Followers. Each crystal filter is followed by an emitter-follower stage. The amplifiers supply the narrow band or wide band signal to the Output Amplifier as either channel is selected by FUNCTION Bandwidth selector switch S1B,

S1C, S1D. A second emitter-follower, Q2, on the Wide Band module takes off the signal ahead of the switch and feeds it to the Audio Amplifier. Thus the signal is always connected through the Wide Band Follower to the Audio output circuits for audio monitoring purposes.

7. Meter Output Amplifiers and Rectifier

From either the Narrow or Wide Band Followers the signal goes to the Output Amplifier module. The stages in this amplifier operate at the second intermediate frequency. The first two, selective tuned, stages are separated from the rest by a shield placed across the module circuit board.

Gain in the first stage is increased 10 db when relay, K1, is closed, actuated by Attenuator switch, S2, when it is placed in the -90 dbm position, as noted in paragraph A.1.b. R2 and part of R4 are shunted out by the relay, increasing the voltage and changing the dc operating point to obtain the additional gain. To insure maximum gain stability, this stage is temperature stabilized by shunting part of the emitter resistor with a thermistor, RT1.

The gain of the second stage, Q2, is adjusted by front panel CAL control, R34, for operational calibration level adjustment. To provide for initial and maintenance calibration the gain of Q3 is varied by adjusting degeneration with the internally mounted control R19. This stage is broadly tuned to the second intermediate frequency.

The meter rectifier circuit is driven by the two stage, R-C coupled, feedback amplifier Q4-Q5. A large amount of negative feedback is used for stability and output linearity. The rectifier circuit is a modified bridge composed of CR1, CR2, C22, C23. Residual IF is filtered out of the meter circuit with L7-C24, L8-C25.

A closed circuit jack in series with the meter circuit is included to provide a recorder output. As long as the resistance introduced into the circuit by the recorder input is not more than 1200 ohms the meter reading will not be affected. This is possible since the feedback amplifier is in effect a constant current source.

8. Audio Amplifier and Detector

From the second Wide Band emitter-follower, Q2, the signal is fed to the Audio module where it is amplified at the second intermediate frequency in a selective tuned amplifier Q1. The output of Q1 is connected to Q2 which functions as either an AM or Sideband detector. An audio amplifier, Q3-Q4, raises the output of the detector to a level suitable for headphone operation. The signal is brought out to the PHONES jack through an emitter-follower, Q5, which makes possible the use of either high or low impedance phones. Audio level is adjusted by front panel AUDIO GAIN control, R39.

9. Carrier Reinsertion Oscillators (On Audio Circuit Board)

When the output of either of the carrier reinsertion oscillators is applied to the input of the detector, Q2, sideband modulation may be recovered. The oscillators are crystal controlled and each is followed by an emitter-follower to prevent excessive loading of the oscillator circuit. The oscillator frequencies are: one 1500 cycles above and one 1500 cycles below the second intermediate frequency. Either oscillator, or neither for AM, is selected by front panel switch S6 which controls the collector current supply to the oscillators.

10. Gain Reference Oscillator

The 1 mc crystal controlled oscillator, Q3, with the compound connected squaring amplifier, Q1, Q2, produces a rectangular signal suitable for the routine calibration of the Voltmeter. Output level is highly stable, variation being less than 0.1 db at normal ambient temperatures. Harmonics of the 1 mc frequency are accentuated in the network composed of L1-C1-R1 so that frequency check points are available over the full frequency range of the Voltmeter. Placing the INPUT Attenuator switch in the CAL position applies B- power to energize the oscillator.

NOTE: Level calibration must be carried out at the 1 mc frequency only.

B. MAIN TUNING AND FREQUENCY LOCK CIRCUITS

Nine circuit board modules mounted in compartments of the MAIN TUNING casting hold the components making up these circuits. See Schematic Diagram Figure 3-5.

1. Main Tuning Oscillator

The Main Tuning Oscillator uses a highly stabilized Colpitts circuit and is tuned by MAIN TUNING capacitor C1 over the range 21.1 mc to 36.1 mc.

a. Locked Mode. In this mode, MAIN TUNING Mode selector switch S5 in the LOCK position, the oscillator is locked on frequency every 100 kc over its full range by means of an error voltage applied to the varactor diode, CR1. The varactor diode is shunted across the oscillator tuning capacitor C1. The error voltage applied to the diode causes its effective capacity to vary in such a direction that the oscillator is maintained in a harmonic relationship with the 100 kc oscillator over a narrow tuning range around each 100 kc harmonic point. Generation of the error voltage is accomplished in the frequency lock circuit to be described in the following paragraphs, 2 through 4.

The Main Tuning Oscillator output passes to the input of two amplifiers, one located on the same circuit board and another separately mounted and designated as the Main Tuning Follower. Oscillator output is fed to this module through a relay, K1, which may be used to introduce an external signal into the Main Tuning Follower

for synchronous tuning operation. See below, sub-paragraph c. The Main Tuning Follower output goes through J8 to the input of the First Modulator for frequency conversion of the main signal to the first intermediate frequency. (Parallel connected jack, J9, is used in alignment procedures only.) The other output of the Main Tuning Oscillator passes through an amplifier, Q2, mounted on the Main Tuning Oscillator circuit board, to the Main Tuning Mixer.

b. Continuous Mode. When the MAIN TUNING Mode selector switch, S5, is placed in the CONT position, collector B- supply is disconnected from the 100 kc Oscillator and the Main Lock Indicator modules. At the same time a fixed bias is applied to the varactor diode, CR1, in the Main Tuning Oscillator circuit. Under these conditions the Voltmeter frequency can be tuned continuously over the full range with the MAIN TUNING Oscillator control, C1, and the frequency to which it is tuned will be indicated by the reading of the MAIN TUNING dial.

c. Tracking Signal Input. For synchronous tuning of the Frequency Selective Voltmeter a signal from an external Tracking Signal Generator is brought in through front panel connector, J2, marked TRACKING SIGNAL MC INPUT. This signal takes the place of the Main Tuning Oscillator output. Control DC to automatically operate relay K1, as well as the external signal, is carried by the center conductor of the connecting cable from the Tracking Signal Generator. When K1 is actuated the B- supply is disconnected from: the Main Tuning Oscillator, Main Tuning Mixer, 100 kc Oscillator and the Main Lock Indicator. At the same time the external signal is connected to the input of the Main Tuning Follower amplifier and fed to the First Modulator. (Refer also to paragraph, Tracking Signal Input Control, under Incremental Tuning Oscillator.) When these two Tracking Signal connections are made, tuning of the Voltmeter is completely controlled by, and is synchronous with, the external Tracking Signal Generator.

2. 100 kc Oscillator and Harmonic Generator

The crystal controlled 100 kc oscillator provides the highly accurate frequency which determines the 100 kc lock points for the Main Tuning Oscillator frequency dial settings. The oscillator, Q1, is connected in a Colpitts circuit. Output is a sine wave which is applied to the input of a Schmitt trigger, Q2-Q3. Since there is an inductance, L2, in the collector circuit of Q3, the Schmitt trigger output has a peaked waveform rich in high order harmonics, which is the desired condition. The oscillator output is isolated from the low impedance input of the Main Tuning Mixer by emitter-follower stage Q4.

3. Main Tuning Mixer

The peaked waveform output of the 100 kc Oscillator and Harmonic Generator is applied to the primary of the Main Tuning Mixer transformer T1 where, due to the resonant rise across the transformer inductance, it becomes still more sharply peaked. The negative swing is cut off by diode CR1, leaving a narrow positive going pulse as the waveform in the transformer primary.

The output of the Main Tuning Oscillator is applied to the center-tap of the secondary of T1. The combined inputs to T1 are applied to diodes CR2-CR3 which, since they conduct in only one direction, allow an output only for the duration of each 100 kc pulse.

The output to the Amplifier Detector is therefore a wave containing components of both the Main Tuning Oscillator frequency and the fundamental and harmonics of the 100 kc frequency. When the Main Tuning Oscillator frequency is exactly a harmonic of the 100 kc oscillator frequency, the output appears as a 100 kc pulse. See Figure 3-1, which shows the pulse after being rectified in the detector.

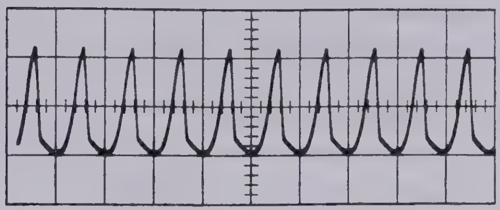
The 100 kc pulses are of constant amplitude provided the Main Tuning Oscillator frequency does not attempt to drift, or the Main Tuning Capacitor is not changed slightly. If either of these situations occur the pulses increase or decrease in amplitude, depending on the direction of attempted frequency change. This change in amplitude is due to change in phase relationships between the 100 kc pulse and the Main Tuning Oscillator signal, and is detected by the following circuits. Such a change generates an error voltage which is immediately applied to the varactor diode and changes its effective capacity slightly. The capacitance change is in the proper direction to maintain the Main Tuning Oscillator frequency in harmonic relation to the 100 kc signal. Thus in the locked condition the frequency of the Main Tuning Oscillator does not vary. Error voltage is developed by change in phase relationships only.

When the Main Tuning Oscillator is not in the locked condition the amplitude of the 100 kc pulses continuously vary. See Figure 3-2. The frequency of the envelope of these variations is the difference between the Main Tuning Oscillator frequency and the frequency of the nearest 100 kc harmonic, and thus will never be greater than 50 kc. In this condition the Main Lock Indicator light goes out.

4. Amplifier Detector, Low-Pass Filter and Main Lock Indicator

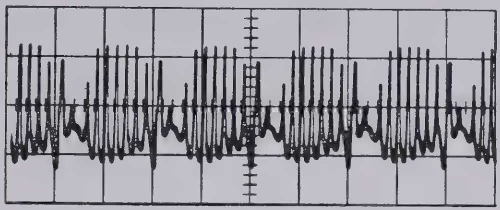
Output from the Main Tuning Mixer is passed through an emitter-follower, Q1, and a common-emitter amplifier, Q2, in the amplifier Detector module and applied to the base of the detector stage, Q3. The detector output is connected to the Low-Pass Filter, a two stage unit with a cutoff frequency of 50 kc.

When the 100 kc pulses out of the Mixer are of constant amplitude, the 100 kc modulation recovered by the detector is removed by the low-pass filter, and the filter output is a dc voltage which is proportional to average pulse amplitude. A change in average pulse amplitude will therefore cause a change in dc voltage. This is the error voltage that is applied to the varactor diode to maintain the Main Tuning Oscillator on frequency, in the locked condition. See Figure 3-3.



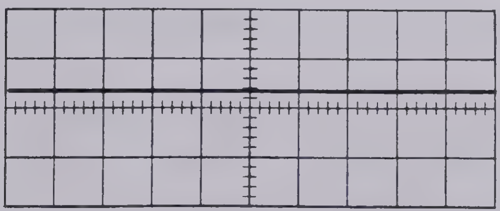
Hor: 10 μs/cm

Figure 3-1. 100 kc Pulses, Locked Waveform, Amplifier Detector Output



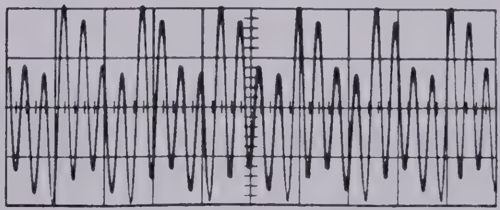
Hor: 50 μs/cm

Figure 3-2. 100 kc Pulses, Unlocked Waveform, Amplifier Detector Output



Hor: 50 μs/cm

Figure 3-3. Locked Waveform, Main Tuning Low Pass Filter Output



Hor: 50 μs/cm

Figure 3-4. Unlocked Waveform, Main Tuning Low Pass Filter Output

When the pulses are continuously varying in amplitude, the unlocked condition, the modulation envelope is detected. Since the envelope frequency is always less than 50 kc, as noted above, this alternating signal passes through the low-pass filter. See Figure 3-4.

The alternating signal out of the low-pass filter is amplified by Q1 in the Main Lock Indicator module and applied to the input of the Schmitt trigger Q2-Q3. This circuit is adjusted to trigger on at a very low ac voltage so that Schmitt-trigger output occurs as soon as the Main Tuning Oscillator lock control is lost. The trigger output flows through relay K1, causing it to open and the LOCKED indicator light to go out.

The same alternating voltage is applied to the varactor diode, but because it fluctuates rapidly it will not cause the oscillator to lock in. When the Main Tuning Oscillator is adjusted so that it is close to a 100 kc harmonic frequency and the alternating voltage frequency is reduced sufficiently, a point is reached at which the lock circuits take control; the low pass filter output becomes dc, the Schmitt trigger in the Main Lock Indicator module is cut off and the LOCKED indicator light comes on.

C. INCREMENTAL TUNING AND FREQUENCY LOCK CIRCUITS

Eight circuit board assemblies make up the Incremental Tuning and Frequency lock circuits. Each board is mounted in a separate compartment of the INCREMENTAL tuning casting which sets on the right side of the instrument. See Schematic Diagram Figure 3-5.

1. Incremental Tuning Oscillator and First LF Amplifier

Adjustment of the Frequency Selective Voltmeter to frequencies between the 100 kc harmonic points selected by the Main Tuning Oscillator control is accomplished with the Incremental Tuning Oscillator. This is a very stable Clapp oscillator covering the frequency range of 200 kc to 310 kc, tuned with front panel mounted capacitor C1. Tuning dial calibration is from -10 to 0 to 100 kc, providing a range that overlaps the 100 kc lock points of the Main Tuning Oscillator.

Oscillator output is amplified in the common-emitter stage Q1, of the First LF Amplifier module. Output then passes through the contacts of relay K1, through two emitter-follower stages, Q2-Q3, to the primary of T1 in the Phase Discriminator module. The power gain of the emitter-follower stages furnishes the signal level required in the primary of T1.

Tracking Signal Generator control for synchronous tuning is fed in through J3 and relay K1. When the connection is made from the external Tracking Signal Generator, dc control voltage carried by the interconnecting cable actuates K1. At this time the Incremental Tuning Oscillator output is disconnected from the circuit, and the Tracking Signal Generator signal is connected to emitter-follower Q2 in its place. See also paragraph B.1.c. above.

2. Second Oscillator

To make the frequency conversion from the First IF band of 21.000-21.110 mc to the second IF of 2.215 mc, the Second Oscillator tunes over the range of 18.785 mc to 18.895 mc. Tuning is accomplished solely by means of varactor diode CR1. This is a voltage variable capacitor connected in the tuned circuit of the Second Oscillator. It functions in a similar manner to the varactor diode in the Main Tuning Oscillator. Adjusting the Incremental Tuning Oscillator causes the voltage across CR1 to be changed by means of the circuits to be described shortly, providing exact control of the Second Oscillator frequency.

Output of Second Oscillator, Q1, is applied to the base of each of two emitter-follower amplifiers, Q2-Q3, both mounted on the Second Oscillator module circuit board. The output of Q2 is fed through J20 to the input of the Second Modulator. (Parallel jack, J19, is provided for use in alignment procedures.) From the output of Q3 the signal is applied to the center tap of the mixer transformer in the Incremental Reference Oscillator and Mixer module through common-emitter isolation amplifier, Q2.

3. Incremental Reference Oscillator and Mixer, and Second LF Amplifier

Control of the Second Oscillator by the Incremental Tuning Oscillator requires the intermediate step in frequency generation provided by the Incremental Reference Oscillator. This is a crystal controlled Colpitts oscillator operating on a frequency of 18.585 mc. The oscillator output is fed into the primary of mixer transformer T1. A signal from the Second Oscillator is fed into the center tap of the secondary of this same transformer through isolation amplifier Q2. These signals are mixed in the output circuit to form a difference frequency which is taken out at the arm of potentiometer, R7. The difference frequency, determined by the tuning of the Second Oscillator, covers the range of 200 to 310 kc.

Mixer output goes to the Second LF Amplifier, made up of a common-emitter and an emitter-follower stage, where the signal is raised to a suitable level for application to the Phase Discriminator.

4. Phase Discriminator and Low-Pass Filter

In this circuit the 200-310 kc frequency of the Incremental Tuning Oscillator is fed into the primary of T1. The 200-310 kc output of the Incremental Reference Oscillator Mixer is fed into the primary of T2. The output connections of the secondaries of these transformers, the diodes CR1-CR2 and associated components form the phase discriminator circuit. When the two input signals are the same frequency, the output appears as a half-wave rectified signal. This signal passes to the Low-Pass Filter. Since the cutoff frequency of this filter is 125 kc, the signal frequency components are filtered out and the output is a dc voltage proportional to the average amplitude of the rectified signal components. As long as the two signals are of the same frequency, the average level of the signal components will change as phase relationships between the two input signals change.

The dc voltage output of the Low-Pass Filter is connected to the varactor diode in the Second Oscillator and controls the frequency of this oscillator. Control is sufficient to keep the Second Oscillator continuously locked to the Incremental Tuning Oscillator over its full range of tuning. Since the Second Oscillator output frequency when mixed with the output of the Incremental Reference Oscillator must generate an output that is the same frequency as that of the Incremental Tuning Oscillator for locking to take place and continue, the control of the Incremental Tuning Oscillator over the Second Oscillator is exact. Therefore, the oscillators are in the phase locked condition for every setting of the Incremental Tuning Oscillator dial.

5. Incremental Lock Indicator

When the input signals to the Phase Discriminator are not exactly the same frequency, a beat frequency output is produced. This beat will be low in frequency and cannot be greater than 110 kc in the extreme case (the difference between 200 and 310 kc), so it readily passes through the low-pass filter to actuate the Incremental Lock Indicator. As in the Main Lock Indicator, any alternating signal at the input is amplified and actuates the Schmitt trigger, causing the contacts of relay K1 to open and the LOCKED indicator light to go out.

The unlocked condition normally will only occur for a short period after the instrument is turned on, or if the Incremental Tuning Oscillator dial is rotated very rapidly. This unlocked condition will be only momentary since the lock circuit is very rapid in its action. Diodes CR3-CR4 and associated circuitry on the Phase Discriminator Module aid in the rapid take-over of control for the locked condition.

D. POWER SUPPLY CIRCUITS

A 16 volt regulated supply provides power for the voltmeter circuits. Input to the supply may be either 115 volts ac or 28 volts dc. The supply is mounted on one circuit board and consists of a solid state rectifier and filter, a series regulator circuit and a relay for ac-dc power supply switch elimination.

The solid state rectifier is transformer coupled to the ac line. Rectifier output is connected to the series regulator through the contacts of relay K1. K1 is connected directly across the ac line and is closed to connect the rectifier output to the series regulator only when the instrument is plugged into a 115 volt ac supply. Otherwise the series regulator is connected to the battery input jacks J6-J7 through diode CR6. This relay connection will not allow both battery and ac supplies to be connected to the series regulator at the same time. Diode CR6 prevents the inadvertent application of battery voltage of the wrong polarity.

When using a battery supply negative polarity must always be connected to J7.

SECTION IV
MAINTENANCE

A. GENERAL

Since the Model 128A is all solid state and is a conservatively designed instrument, it may be expected to provide many hours of trouble free operation.

If trouble should occur, probable expected order of trouble is: incandescent panel lamp failure, development of noise in most frequently used controls, power supply diode failure, increased leakage or complete failure of transistors, increased leakage of capacitors and change in value of resistors.

If trouble shooting becomes necessary, a good understanding of circuit operation and signal flow paths as outlined in the Theory of Operation, Section III, and the Schematic Diagram, Figure 3-5, will aid greatly in tracing the cause of the trouble.

Signal level voltages at numerous points along the signal flow path are given in the Signal Levels Block Diagram Figure 4-1. Voltages indicate the rms signal level to be introduced at that point to obtain a 0 db reading on the meter of the 128A instrument. The frequency of the signal will be the frequency that normally occurs at that point as indicated on the Block Diagram. Signal levels may be expected to vary somewhat in different instruments.

Wave forms, frequency and amplitude of the Frequency Lock circuits are given in Figures 4-4, 4-7, 4-8.

Location of modules and calibration adjustment points is given in Figures 4-2, 4-3, 4-5, 4-6, 4-9, 4-10.

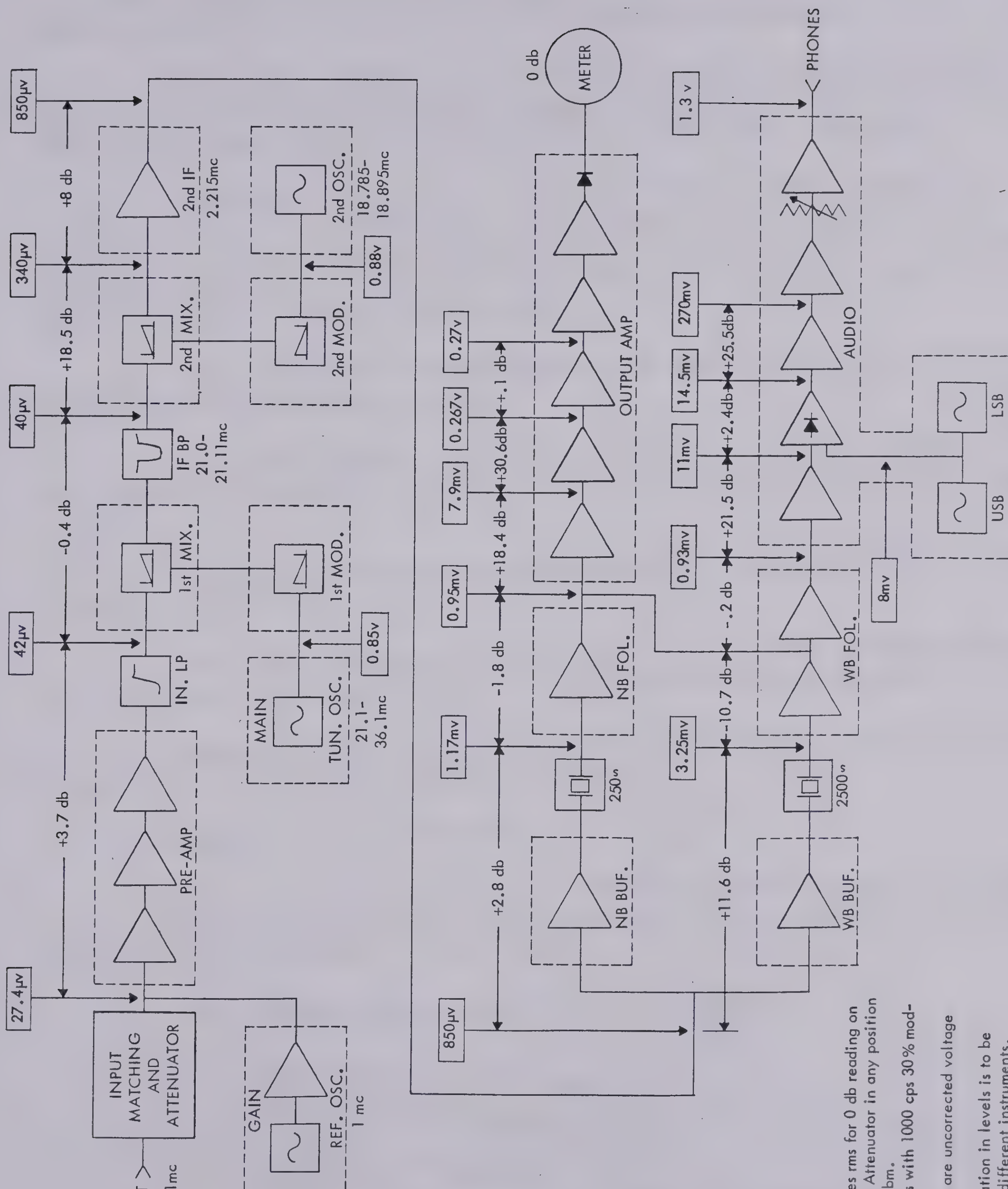
The circuit boards have a number screened on the component side. This is the same number as that which appears within the dashed-line box indicating the module on the schematic diagram. The name of the module is etched on the foil side of the circuit boards. This name also is the same as that appearing on the Schematic Diagram.

The following general outline of trouble tracing is suggested:

1. Make sure all cable connectors are properly connected and screwed up snugly.

2. Check power supply output voltage. It should be approximately −16 volts dc.

3. Using a wideband oscilloscope (such as a Tektronix 543) check for proper output



NOTES:
All voltages rms for 0 db reading on meter, Input Attenuator in any position except -90 dbm.
Audio tests with 1000 cps 30% modulation.
DB figures are uncorrected voltage ratios.
Some variation in levels is to be expected in different instruments.

Figure 4-1. Signal Levels Block Diagram

at J8, Main Tuning Follower, and at J20, Second Oscillator. This check will localize the trouble to either of the Tuning modules or to the signal flow path modules.

4. If the output of either Tuning module is improper as to frequency, waveform or amplitude, Figure 4-4a or 4-7a, the various module circuits should be carefully checked using the waveforms of Figures 4-4, 4-7, and 4-8 as a guide to proper operation.

5. If tuning and module output waveforms appear to be correct, the trouble is probably in the signal flow path modules. Refer to Figure 4-1 and introduce a signal of the proper amplitude and frequency at a point midway along the signal path. For example: a 2.215 mc, 340 microvolt signal into the input of the second IF amplifier. (Tuning modules must be connected and operating for these tests.)

6. If the panel meter reads approximately 0 db, select a point farther back toward the Input to introduce the next test signal.

7. If panel meter reading varies widely from 0 db, or no reading is obtained for the test of paragraph 5 above, select a point closer to the meter and introduce the proper test signal.

8. Follow the above procedure until faulty module is bracketed between two closely spaced test points.

Note that the attenuator must not be placed in the -90 dbm position for these tests. In this position an extra 10 db gain is introduced into the Output Amplifier.

9. When the faulty module has been located, check the signal flow through that module, and check individual components as necessary.

B. ALIGNMENT AND CALIBRATION

No change in adjustments should be made unless the required test equipment is available and complete alignment procedures may be carried out. In this procedure the instrument being aligned will be referred to as "the voltmeter".

1. Test Equipment Required (Items Listed or Equivalent)

   a. Signal Generator, HP 606A
   b. Clip-on Milliammeter, HP 428B
   c. DC Vacuum Tube Voltmeter, HP 412A
   d. AC Vacuum Tube Voltmeter, HP 400L
   e. VHF Attenuator, HP 355B
   f. Frequency Counter and Converter, HP 524C and 525A
   g. Oscilloscope, Tektronix 543
   h. 50 ohm Coaxial Termination Load, Sierra Model 160-1

2. Power Supply

a. Connect the voltmeter to a variable 115 volt AC source. Connect the DC VTVM to TP2 on the bottom side of the chassis.

b. Adjust the AC source to 115 volts and switch the voltmeter on.

c. DC VTVM should read -16.0 volts. If not, adjust R2 in the power supply until a reading of -16.0 volts is obtained.

d. Connect the Clip-On Milliammeter to the violet wire between the power supply PCB and F2. Full load DC current should be approximately 230 ma.

e. Vary the AC source voltage between 105V and 125V. There should be no change in the DC VTVM reading. A change would indicate voltage regulator trouble.

f. Connect the DC VTVM to the external battery input jacks, J6-J7. Short CR6 in the power supply with a clip lead and short the three relay contact springs (K1 in power supply) together. The DC VTVM should read -16 volts. Remove the clip lead from CR6 while leaving the relay contacts shorted and observe that voltage is removed from J6-J7. This checks proper operation of CR6 which is to prevent wrong polarity connection of an external battery supply.

3. Audio Circuits

It is necessary to remove the Audio cover shield to gain access to all adjustments on the Audio module.

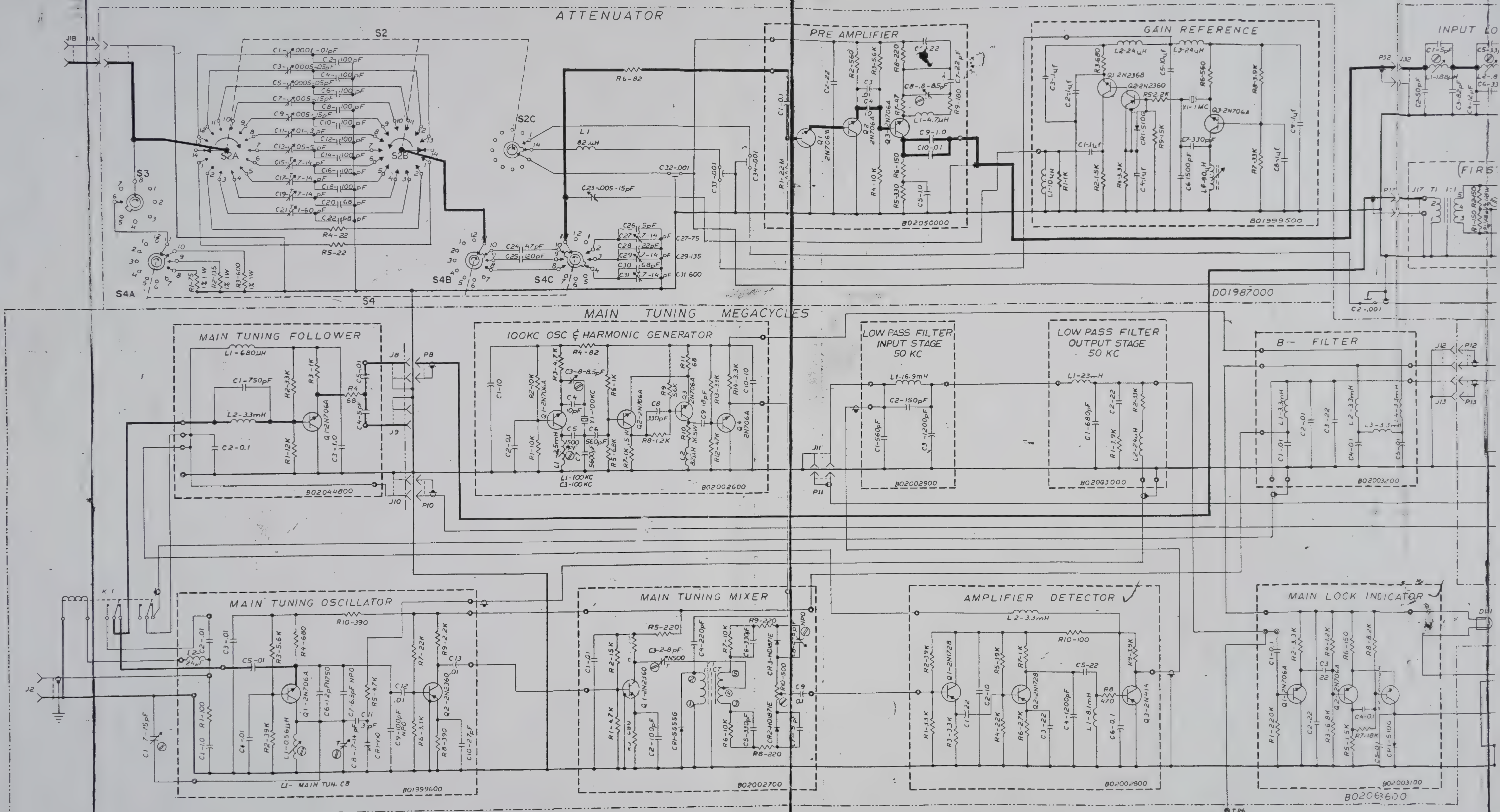
a. Disconnect J23, input to IF Buffers and P30 and P31, the B- connections to the tuning oscillators.

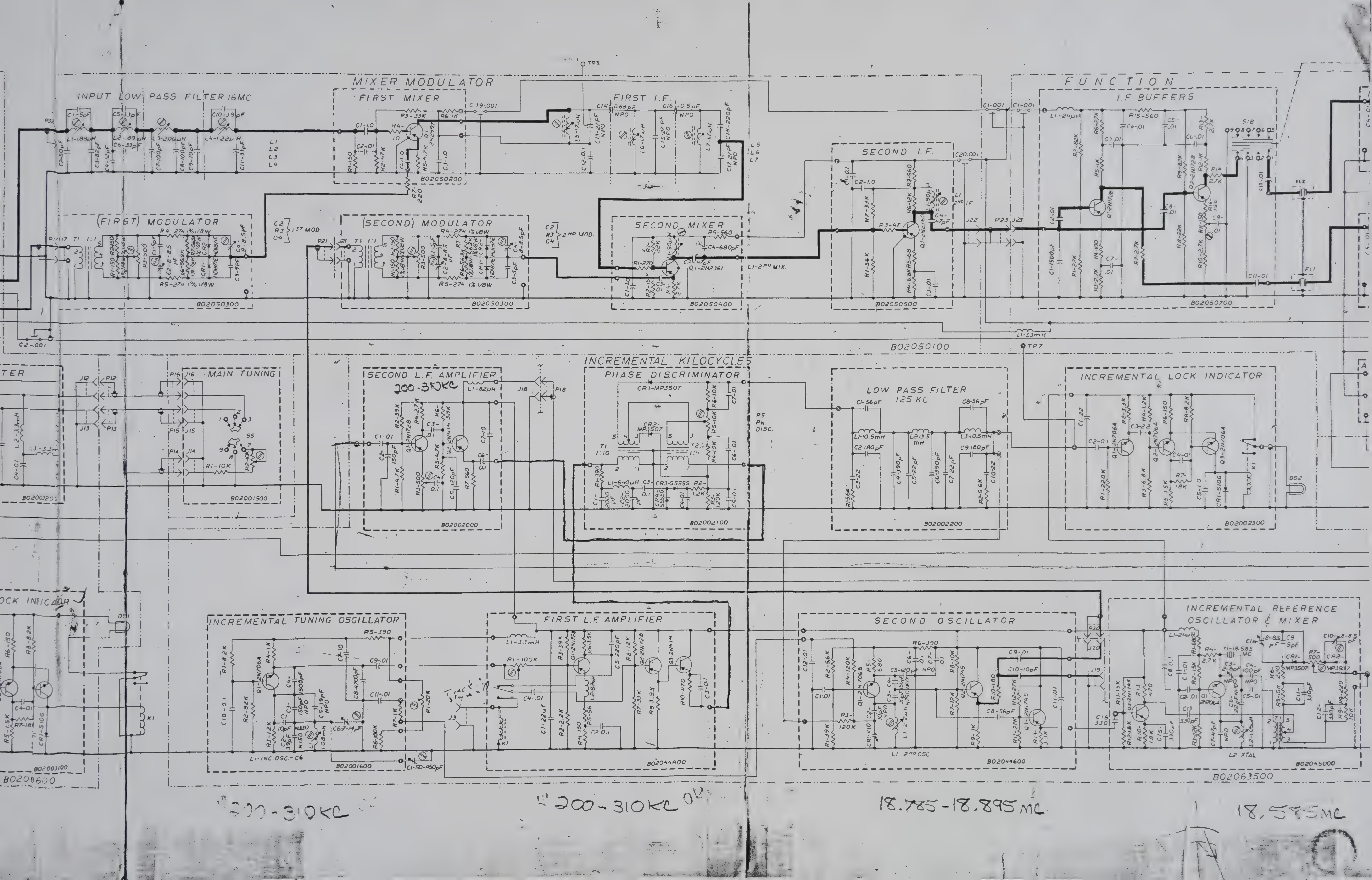
b. Connect the Frequency Counter to the vertical amplifier output of the Oscilloscope.

c. Connect the vertical input of the Oscilloscope to the junction of C20-R28 on the Audio module and turn the Detector Mode switch to LS.

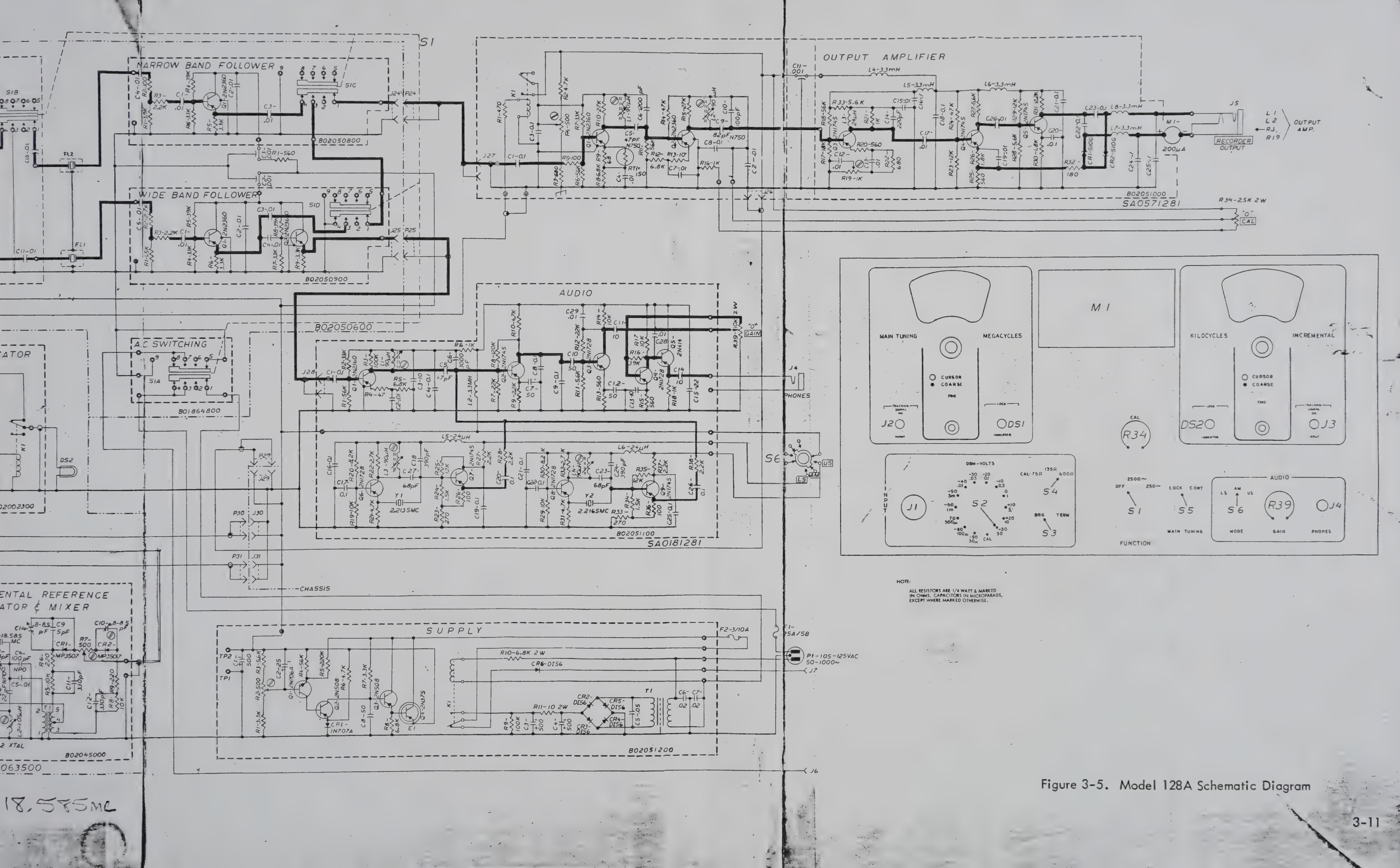
d. Adjust L3 on the Audio module for maximum indication on the Oscilloscope (approximately 2.0 volts p-p) and check that the frequency reading on the counter is 2.2135 mc ±110 cps.

e. Connect the Oscilloscope to the junction of C26-R38 on the Audio module and turn the Detector Mode switch to US.


ATTENUATOR
PRE AMPLIFIER
B02050000
GAIN REFERENCE
B01999500
INPUT LO
D01987000
MAIN TUNING MEGACYCLES
MAIN TUNING FOLLOWER
B02044800
100KC OSC & HARMONIC GENERATOR
B02002600
LOW PASS FILTER INPUT STAGE 50 KC
B02002900
LOW PASS FILTER OUTPUT STAGE 50 KC
B02003000
B- FILTER
B02003200
MAIN TUNING OSCILLATOR
B01999600
MAIN TUNING MIXER
B02002700
AMPLIFIER DETECTOR
B02002800
MAIN LOCK INDICATOR
B02003100
B02003600



INPUT LOW PASS FILTER 16MC
MIXER MODULATOR
FIRST MIXER
FIRST I.F.
FUNCTION
I.F. BUFFERS
SECOND I.F.
(FIRST) MODULATOR
(SECOND) MODULATOR
SECOND MIXER
B02050300
B02050200
B02050400
B02050500
B02050700
B02050100
MAIN TUNING
SECOND L.F. AMPLIFIER
200-310KC
INCREMENTAL KILOCYCLES
PHASE DISCRIMINATOR
LOW PASS FILTER
125 KC
INCREMENTAL LOCK INDICATOR
B02001200
B02001500
B02002000
B02002100
B02002200
B02002300
INCREMENTAL TUNING OSCILLATOR
FIRST L.F. AMPLIFIER
SECOND OSCILLATOR
INCREMENTAL REFERENCE
OSCILLATOR & MIXER
B02001600
B02044400
B02044600
B02045000
B02063500
B02003100
200-310KC
200-310KC
18.785-18.895MC
18.585MC



NOTE:
ALL RESISTORS ARE 1/4 WATT & MARKED IN OHMS. CAPACITORS IN MICROFARADS, EXCEPT WHERE MARKED OTHERWISE.

Figure 3-5. Model 128A Schematic Diagram

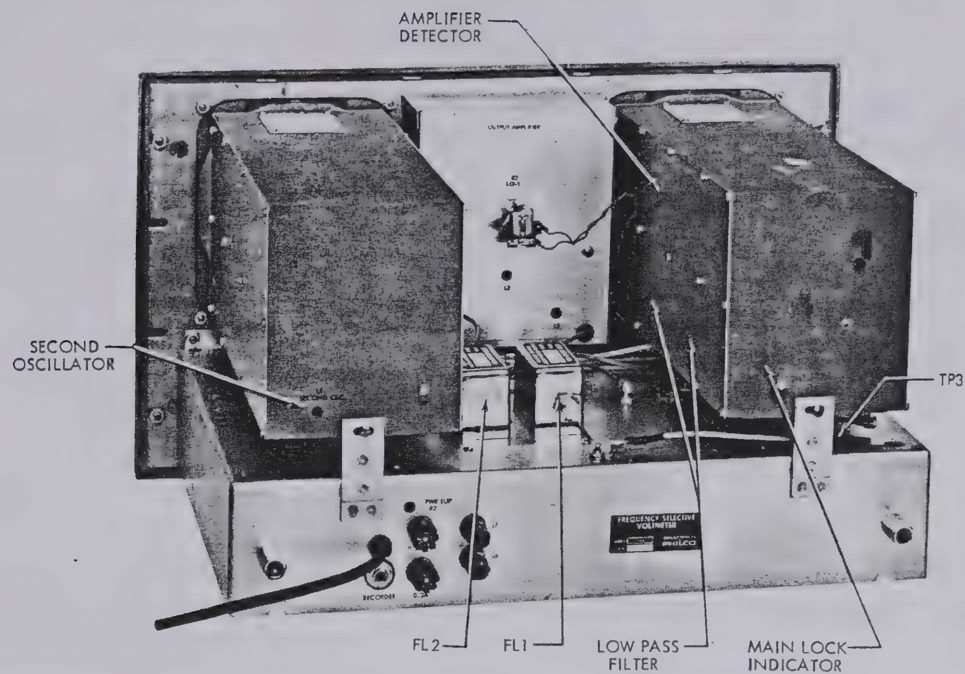


Figure 4-2. Rear View, Module Location

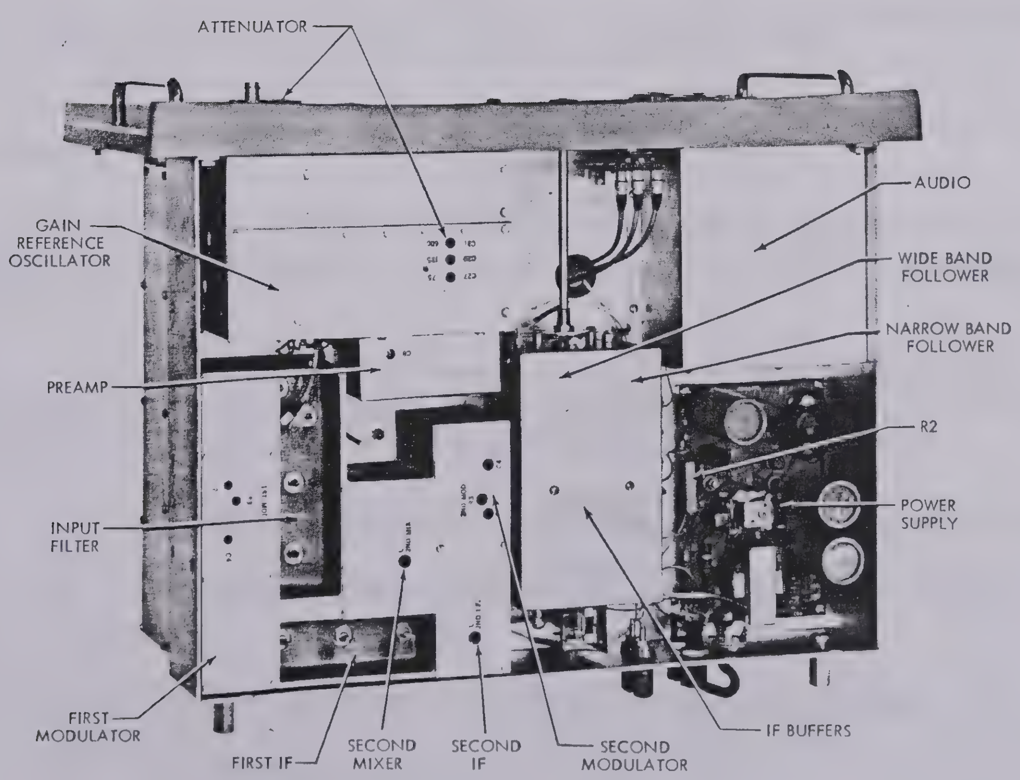


Figure 4-3. Bottom View, Module Location

f. Adjust L4 for maximum indication on the Oscilloscope (approximately 2.0 volts p-p) and check that the frequency reading on the counter is 2.2165 mc ±110 cps.

g. Connect the Signal Generator to J28 (input to the audio module) and the Oscilloscope to the base of Q2 on the Audio module. Tune the Signal Generator to 2.215 mc and the output to approximately 700 μv.

h. Turn the Detector Mode switch to AM and adjust L1 for maximum indication on the Oscilloscope.

i. Modulate the Signal Generator signal 30% with the internal 1 kc frequency.

j. Connect the AC VTVM to the output jack J4 and turn the Audio Gain control R39 fully clockwise. Output voltage for each setting of the Detector Mode switch should be approximately as follows:

AM - 3.0 volts modulated
LS - 3.0 volts unmodulated
US - 3.0 volts unmodulated

4. Output Amplifier

a. Connect the Signal Generator to J27 or P24 (input to the output amplifier module), tune to 2.215 mc and set the output to approximately 500 μv.

b. Set the voltmeter front panel CAL control and R19 on the output amplifier PCB to center position.

c. Set the voltmeter Attenuator switch to -90 db, 75 ohm/TERM. Check that the relay K1 on the output amplifier PCB operates as Attenuator switch is moved from -80 db to -90 db position.

d. Adjust L1 and L2 in the output amplifier for maximum deflection on the voltmeter panel meter, approximately 0 db. Overall gain with R19 and CAL controls centered and with Attenuator in the -90 db position should be 55 to 60 db.

e. Set the CAL control (or Signal Generator output) for an exact 0 db reading.

f. Switch the voltmeter Attenuator to the -80 db position and raise the Signal Generator output 10 db.

g. Adjust R4 on the output amplifier PCB for a 0 db reading.

h. Reconnect cable to J27.

5. Crystal Filter

a. Connect the Signal Generator to J23 (input to the IF Buffers), tune to 2.215 mc and set output to approximately 500 μv.

b. Set the voltmeter front panel Bandwidth switch to 2500 ~ and set the CAL control (or Signal Generator output) for an exact 0 db reading on the voltmeter panel meter.

c. Turn Bandwidth switch to 250 ~ and adjust R11 on the IF Buffer PCB for a 0 db reading.

d. Reconnect cable to J23.

6. Second IF

a. Remove the T shaped cover from the IF casting. Tune the Signal Generator to 2.215 mc and set the output to approximately 30 μv.

b. Using a 0.1 μf capacitor connect the Signal Generator to the input of the second mixer (feed-through insulator with orange wire).

c. Set the voltmeter Bandwidth switch to 2500 ~.

d. Adjust L1 in the second IF and L1 in the second mixer for maximum deflection on the voltmeter panel meter.

e. Replace IF cover.

7. First IF

a. Remove the rectangular cover from the IF casting. Loosen the locknuts on L5, L6, L7 on the First IF.

b. Connect the B- plug P31 to J31 to provide B- for the Incremental Tuning oscillator. Set Incremental Tuning dial to 0.0 position.

c. Tune the Signal Generator to 21.1 mc set to approximately 50 μv output, and connect to the First Modulator output at the 220 ohm feed-through resistor R7. Adjust Signal Generator output for a mid-scale reading on the voltmeter panel meter.

d. Adjust L5, L6, L7 in the First IF for maximum deflection on the voltmeter panel meter, decreasing the Signal Generator output to keep the meter on scale if necessary. Signal Generator output should be approximately 25 μv for a 0 db panel meter reading when amplifier is properly aligned.

e. Reconnect the B- connection P30 to the main tuning oscillator. Set the Main Tuning dial to 1.0 mc. Set the voltmeter input Attenuator to -80 db, 75 ohm/TERM and set the Bandwidth switch to 250 ~.

f. Tune the Signal Generator to 1 mc, set the output to approximately -80 db and connect to the voltmeter input.

g. Readjust all inductances for maximum panel meter deflection, L5, L6, L7 in the First IF, L1 in the Second Mixer, L1 in the Second IF, L1, L2 in the output amplifier.

h. Connect the AC VTVM to the audio output jack J4, set Detector Mode switch to either US or LS and tune L1 in the audio amplifier to maximum indication on the AC VTVM.

8. First Modulator

a. Tune the Signal Generator to 50 kc, set the output to 0 db and connect to the input of the voltmeter.

b. Set the voltmeter Attenuator to 0 db, 75 ohm/BRG and the Bandwidth switch to 250 ~. Set the Main Tuning dial to 0.0 mc and tune the Incremental Tuning oscillator to the 50 kc signal. Voltmeter in Locked condition.

c. Adjust R3, C2, C4 in the First Modulator for maximum voltmeter panel meter deflection.

d. Remove the Signal Generator signal, switch to 2500 ~ and tune the Incremental Tuning oscillator toward 0 kc until the meter reads almost full scale.

e. Adjust R3, C2, C4 in the First Modulator to minimize meter reading while tuning the incremental oscillator further toward 0 until an adjustment minimum is reached. A 3 kc setting on the incremental oscillator should cause a meter reading of less than -10 db (with output of preamplifier disconnected).

9. Second Modulator

a. Set the voltmeter Bandwidth switch to 2500 ~ and the Main Tuning dial to 0.1 mc. Set the input Attenuator to -90 db, 75 ohm/TERM.

b. Tune the Incremental Tuning oscillator slowly from 0 to 100 kc. Notice the spurious responses at 23, 54, 78 and 100 kc.

c. With first modulator detuned, adjust C10, C14, R7, in the Incremental Reference Mixer to minimize the spurious responses noted above. (Main Tuning set at 0.1 mc and Incremental Tuning from 100 kc to 0.) After adjustment repeat para. 8.

d. Set the Main Tuning dial to 0.3 mc and adjust R3, C2, C4 in the Second Modulator to reduce the spurious responses at 23, 54 and 78 kc to below -115 db on the panel meter.

e. Set the Main Tuning dial to 0.1 mc and check for a spurious response between 53 and 57 kc. Readjust R3, C2, C4 in the First Modulator slightly to reduce this response to below -115 db.

f. Set the Bandwidth switch to 250 ~. Tune the incremental tuning oscillator slowly from 0 to 100 kc. All spurious responses should be below -115 db.

g. If a spurious signal shows up around the 50 kc point on the Incremental Tuning dial in the wideband (2500 ~) position but not in the narrow band (250 ~) position, readjust the first modulator until this spurious signal disappears. If First Modulator is properly aligned, this spurious will not appear.

h. Check for spurious responses throughout range of MAIN TUNING oscillator in the Unlocked condition. If any spurious responses are present, replace First Mixer transistor and repeat para. 8.

10. Input Filter

a. Tune the Signal Generator to 7.8 mc, set output to -91.75 db, terminate with 50 Ω coaxial termination load and connect to the voltmeter input.

b. Set the voltmeter Attenuator to -90 db. 75 ohm/BRG and tune in the 7.8 mc signal. Adjust the CAL control for a panel meter reading of 0 db.

c. Tune the Signal Generator to 50 mc, raise the output by 70 db and adjust L1 in the Input Low-pass Filter for a minimum reading on the voltmeter panel meter.

d. Tune the Signal Generator to 21.1 mc and adjust L2 in the Input Low-pass Filter for a minimum reading on the panel meter.

e. Minimum adjustment value in both step c. and d. should be below the specified attenuation level (70 db), (meter reading below 0 db). If not see below.

f. If attenuation is greater than 70 db (meter reads below 0 db) tune L4 in the Input Low-pass Filter in the inward direction. If attenuation is less than 70 db (meter reads above 0 db) tune L4 in the outward direction. Recheck steps c. and d. above and retune L4 until the desired -70 db level is reached. Recheck and retune L1 if necessary.

g. Tune the Signal Generator to 15.1 mc and adjust L3 in the Input Low-pass Filter for maximum reading on the panel meter.

11. Tracking and Locking, Main Tuning Oscillator

If the Main Tuning adjustments are badly out of line, follow the procedure given in paragraph a. If normal service realignment check is to be performed, start procedure with paragraph b. For module location and waveforms refer to Figures 4-4, 4-5, 4-6.

a. Adjustments, Main Tuning Oscillator

Additional test equipment required for these adjustments:

RF Microvoltmeter with High Impedance Probe, Millivac MV 28B or equivalent.

RF Oscilloscope, Tektronix 581 or equivalent.

(1) Attach the probe of the RF Oscilloscope to J9. With plates of the Main Tuning capacitor fully meshed, frequency about 21 mc, the voltage should be 2.7 volts p-p. See Figure 4-4a.

(2) Set Main Tuning Mode to CONT. Set Cursor Index to midrange.

(3) Connect the Frequency Counter with an adapter cable to J9.

(4) Set the tuning dial to 0.0 mc and check that tuning capacitor is 1/16" from full mesh.

(5) Adjust L1 on the Main Tuning oscillator until the counter reads approximately 21.1 mc. (Tuning dial at 0.0 mc.)

(6) Rotate the tuning dial to 15.0 mc and adjust C8 until the counter reads approximately 36.1 mc.

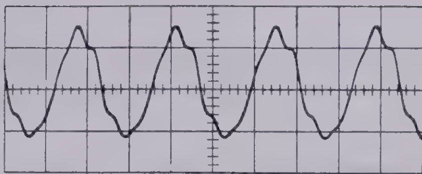
(7) Repeat steps (5) and (6) until counter readings are within ±10 kc.

(8) Set Main Tuning Mode switch to Lock.

(9) Attach probe of Oscilloscope to terminal ~~2~~ 1 of T1 in the Main Tuning Mixer and check the 100 kc positive-going pulse. See Figure 4-4. If no pulse is present, adjust L1 in the 100 kc oscillator until a pulse of maximum amplitude is obtained.

(10) Switch power supply off and on several times to check for reliable starting of the oscillator. Slight readjustment of L1 may be necessary for reliable operation.

(11) Attach the high impedance probe of the RF microvoltmeter to terminal 2 of transformer T1 in the Main Tuning Mixer. Keep the Main Tuning dial at 0.0 mc

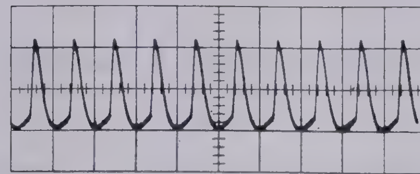


Vert: 1 V/cm

Hor: 20 nsec/cm

(581 Oscilloscope)

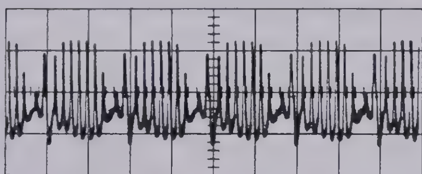
a. Main Tuning Oscillator output, capacitor plates fully meshed. Across 150 ohm dummy load connected to output of Main Tuning Follower output J8.



Vert: 1 V/cm

Hor: 10 usec/cm

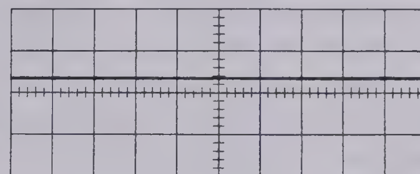
b. Main Tuning Amplifier Detector output, collector of Q3. Locked waveform.



Vert: 1 V/cm

Hor: 50 usec/cm

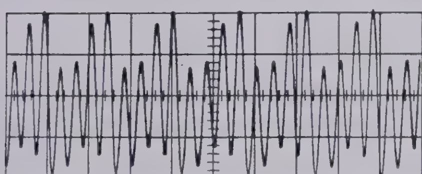
c. Main Tuning Amplifier Detector output, collector of Q3. Unlocked waveform.



Vert: 2 V/cm

Hor: 50 usec/cm

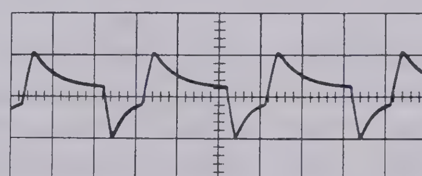
d. 50 KC Low-Pass Filter output, junction of L1, C1, C2, R2. Locked waveform.



Vert: 2 V/cm

Hor: 50 usec/cm

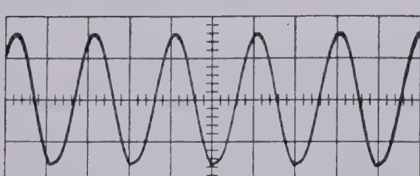
e. 50 KC Low-Pass Filter output, junction of L1, C1, C2, R2. Unlocked waveform.



Vert: 2 V/cm

Hor: 10 usec/cm

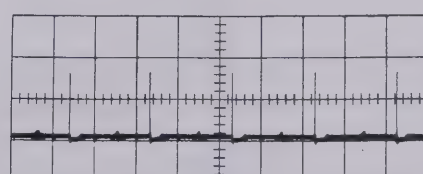
f. Main Lock Indicator, junction of R5, R7, C4. Unlocked waveform.



Vert: 1 V/cm

Hor: 5 usec/cm

g. 100 KC Oscillator and Harmonic Generator, oscillator output, junction of C5, C6, C7.

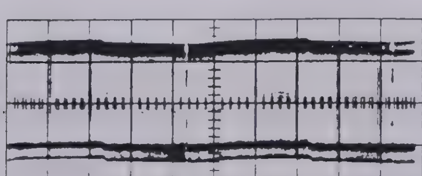


Vert: 5 V/cm

Hor: 5 usec/cm

(581 Oscilloscope)

h. 100 KC Pulse. Terminal 2 of transformer T1 in Main Tuning Mixer.



Vert: 5 V/cm

Hor: 2 usec/cm

(581 Oscilloscope)

i. Main Tuning Mixer, RF input. Terminal 4 of transformer T1.

Vert: 5 V/cm

Hor: 5 usec/cm

(581 Oscilloscope)

j. Main Tuning Mixer output. Arm of R10.

Figure 4-4. Main Tuning Module, Waveforms

position. Adjust pulse level with C9 in the 100 kc harmonic generator until the microvoltmeter reads 2.5 volts.

(12) Attach the microvoltmeter probe to terminal 4 of T1 in the Main Tuning Mixer and adjust the RF level with C3 until the microvoltmeter reads 0.55 volts.

(13) To adjust the balance of the Main Tuning Mixer, attach the probe of the Oscilloscope to TP6 on the Main Lock Indicator. Set sweep speed to 50 μsec and the preamp to DC. The DC voltage range present, in locked condition, should be equal to or greater than 5 volts with the tuning capacitor plates in fully meshed position and equal to or greater than 2 volts with the tuning capacitor plates in the fully opened position, with no ac present over the whole range. This locking voltage range is controlled by C8 and R10 in the Main Tuning Mixer. The optimum position of these controls is arbitrary and can only be determined by a "trial and error" procedure.

(14) If ac shows up on the dc trace, reduce level slightly with C3 in Main Tuning Mixer. If the locking voltage range requirement cannot be met, readjust C3 in the Main Tuning Mixer and C9 in 100 kc oscillator. Check that no AC is present throughout range.

(15) Fasten side panels securely to the module. Connect the Frequency Counter with an adapter cable to J9. Tune the Counter converter to 36.1 mc. Set the Main Tuning dial to the locked frequency position at or closest to the 15.0 mc dial mark. Adjust C3 in the 100 kc oscillator (use small insulated tool) until the counter reads 36.1 mc ±2 cps.

b. Main Tuning Oscillator Tracking and Locking Adjustments

(1) Connect the Frequency Counter to J9 on the Main Tuning oscillator. Turn the Main Tuning mode switch to CONT.

(2) Check that the end frequencies are within ±10 kc of 21.1 and 36.1 mc (0.0 and 15.0 on the dial). If not refer to paragraphs a. (7)-(9) above.

(3) Turn the Main Tuning Mode switch to lock. Check the frequency locking at each megacycle mark and note the tuning dial settings. If all frequencies read either high or low on the dial, shift the dial disc by loosening its set screw to achieve an even reading distribution. Tighten setscrew after dial disc is shifted. Recheck (2) and readjust the end frequencies according to paragraphs a. (7)-(9) if necessary.

(4) Starting at the high end check in 100 kc steps that frequency locking occurs at each step within the width of the dial mark. Adjust misalignments by slightly bending the outside capacitor plates. Access to the plates is through a hole in the top of the casting. (This step necessary only after major parts replacement or major overhaul.)

(5) Set the dial to exactly 1 mc and note counter reading. Switch the Main Tuning mode switch to CONT. Adjust R2 on the Main Tuning switch until the counter reading in CONT position is within ±1 kc of the counter reading in LOCK position.

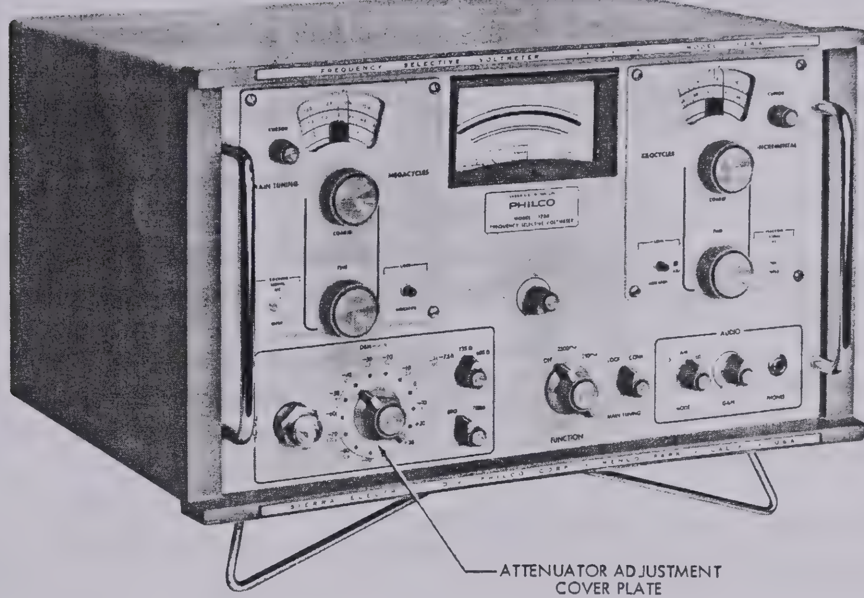


Figure 4-5. Front View, Module Location

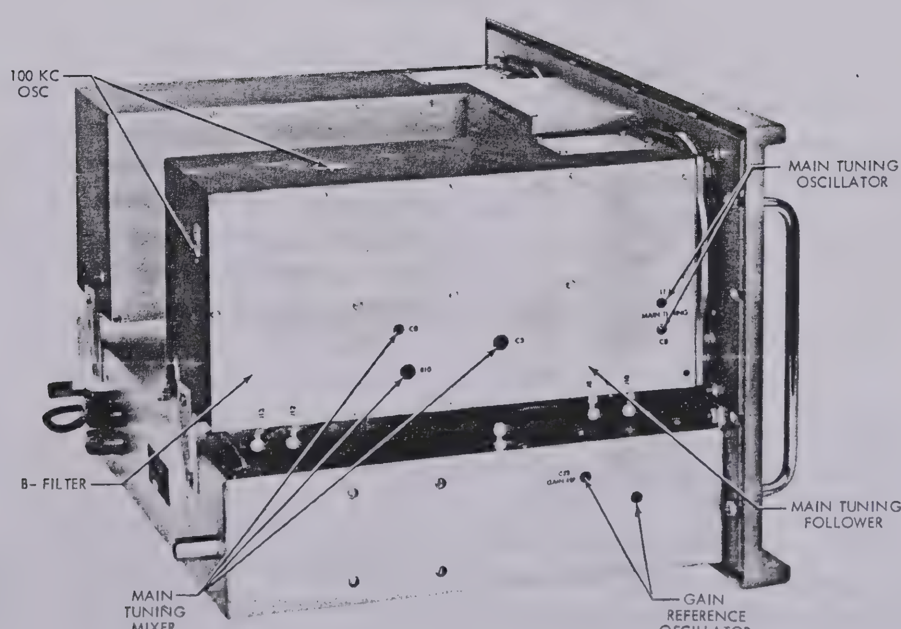


Figure 4-6. Left Side View, Module Location

12. Incremental Tuning Oscillator, Tracking and Locking

If the Incremental Tuning adjustments are badly out of line, follow the procedure in paragraph a. If normal service realignment is to be performed, start procedure with paragraph b. For waveforms and module location refer to Figures 4-7 through 4-10.

a. Adjustments, Incremental Tuning Oscillator, Locking.

19.0

(1) Attach probe of Oscilloscope to J20. The frequency should be about ~~10~~ mc and the voltage 6.2 volts p-p. See Figure 4-7a.

(2) Attach the Oscilloscope probe to terminal 2 of T1 in the Incremental Reference Mixer and check for the 1 volt p-p signal. See Figure 4-7b. If no signal is present, adjust L2 of the crystal oscillator until the signal appears and adjust for maximum amplitude.

(3) Switch the power supply off and on several times to check for reliable starting of the oscillator. Slight readjustment of L2 may be necessary to assure proper operation.

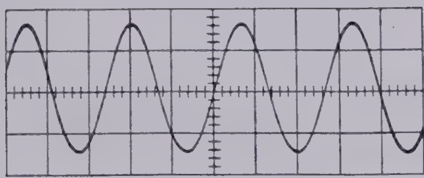
(4) Attach the probe of the Oscilloscope to terminal 2 of T1 in the Incremental Reference Mixer and connect the Frequency Counter to the output of the vertical amplifier of the oscilloscope. Adjust C3 in the Incremental Reference oscillator until the counter reads 18.585 mc ±10 cps. Disconnect counter.

(5) Attach the Oscilloscope probe to the connection between R1 and the base of Q1 in the First LF amplifier. Keep the Incremental Tuning oscillator capacitor plates fully meshed and adjust R1 until the voltage corresponds to the voltage of Figure 4-7g.

(6) Set the Oscilloscope attenuator to 1V/cm and the preamplifier to DC. Short the oscilloscope probe to ground and adjust the vertical position control until the trace is on a reference grid line (zero volts DC reference). Attach the probe to TP7 on the incremental lock indicator. Adjust R3 in the second LF amplifier to mid-position and the tuning capacitor of the Incremental Tuning oscillator to full open position. Adjust L1 in the Second Oscillator until a DC voltage trace appears on the oscilloscope. Then adjust the DC voltage with L1 to the previously selected reference line (zero volts DC). If difficulties are encountered in obtaining a DC voltage, adjustment of R5 in the Phase Discriminator may be necessary.

(7) As soon as DC voltage is present the lock indicator light, below the tuning dial, should come on. The light should be off if AC voltage is present.

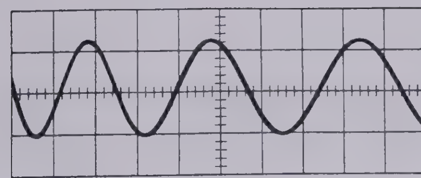
(8) Attach the oscilloscope probe to the output of the First LF amplifier (terminal 2 of T1 in Phase Discriminator) and fully mesh the Incremental Tuning capacitor plates. Readjust R1 in the First LF amplifier until the waveform corresponds to the voltage of Figure 4-7i.



Vert: 2 V/cm

Hor: 20 nsec/cm

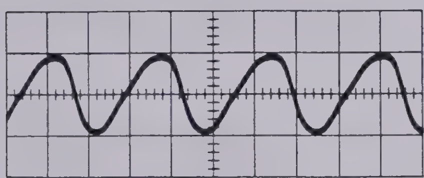
a. Second Oscillator output at J20.



Vert: 2 V/cm

Hor: 20 nsec/cm

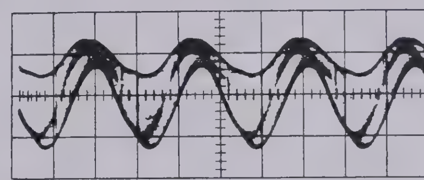
b. Incremental Reference Oscillator and Mixer, Crystal Oscillator output, terminal 2 of transformer T1. Second Oscillator disconnected.



Vert: 2 V/cm

Hor: 20 nsec/cm

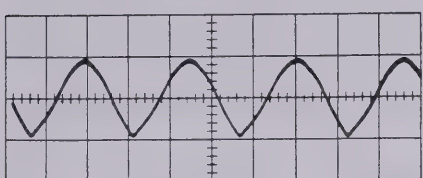
c. Incremental Reference Oscillator and Mixer, Second Oscillator input, terminal 4 of transformer T1.



Vert: 0.1 V/cm

Hor: 2 usec/cm

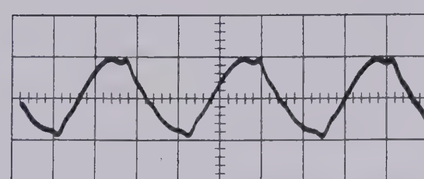
d. Incremental Reference Oscillator and Mixer output, arm of R7. Incremental Tuning Oscillator capacitor plates meshed.



Vert: 2 V/cm

Hor: 2 usec/cm

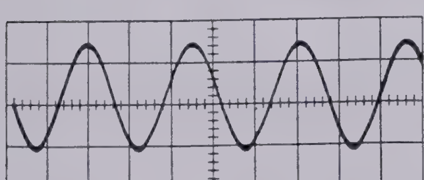
e. Second L.F. Amplifier output. Terminal 1 of transformer T2 in Phase Discriminator. Incremental Tuning Oscillator capacitor plates meshed.



Vert: 2 V/cm

Hor: 1 usec/cm

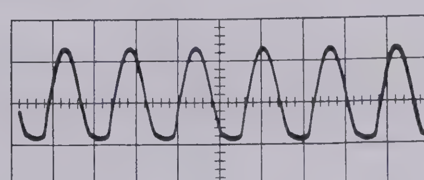
f. Second L.F. Amplifier output. Terminal 1 of transformer T2 in Phase Discriminator. Incremental Tuning Oscillator capacitor plates open.



Vert: 0.2 V/cm

Hor: 2 usec/cm

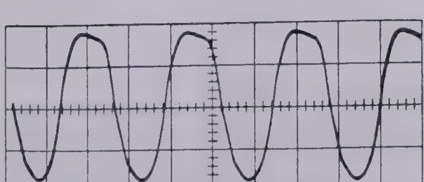
g. First L.F. Amplifier input, base of transistor Q1. Incremental Tuning Oscillator capacitor plates meshed.



Vert: 0.5 V/cm

Hor: 2 usec/cm

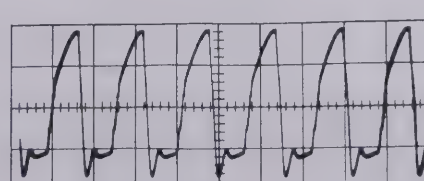
h. First L.F. Amplifier input, base of transistor Q1. Incremental Tuning Oscillator capacitor plates open.



Vert: 2 V/cm

Hor: 2 usec/cm

i. First L.F. Amplifier output. Terminal 2 of transformer T1 in Phase Discriminator. Incremental Tuning Oscillator capacitor plates meshed.



Vert: 2 V/cm

Hor: 2 usec/cm

j. First L.F. Amplifier output. Terminal 2 of transformer T1 in Phase Discriminator. Incremental Tuning Oscillator capacitor plates open.

Figure 4-7. Incremental Tuning Module, Waveforms I

(9) Attach the oscilloscope probe to the output of the Second LF amplifier (terminal 1 of T2 in Phase Discriminator). Readjust R3 in the Second LF amplifier until the waveform corresponds to the voltage of Figure 4-7e.

(10) Attach the oscilloscope probe to the output of the 125 kc Low-Pass Filter (TP7). Rotate the Incremental Tuning capacitor slowly through its range and observe the DC trace on the oscilloscope. If in some portions of the capacitor range a sine wave appears, readjust R5 in the Phase Discriminator. The oscilloscope trace must be DC throughout the tuning capacitor range.

(11) Switch the power supply off and on at every 10 kc increment over the tuning capacitor range. Allow at least 1/2 minute off-time of the power supply. Each time the power supply is switched on, the oscilloscope trace must return to dc. If it does not, slight readjustment of R1 in the First LF amplifier and/or R3 in the Second LF amplifier is necessary.

(12) Rotate the Incremental Tuning capacitor rapidly through its range. The locking system may momentarily go out of the locked condition and an ac voltage be present at the 125 kc Low-Pass Filter output (TP7). If the locking system does not immediately return to a stable dc condition, compensating readjustments of R1 in the First LF amplifier, R3 in the Second LF amplifier and R5 in the Phase Discriminator are necessary.

(13) Connect the high impedance probe of the RF microvoltmeter to the inside connection of J20. Check that the output voltage over the frequency range of the oscillator is 0.8 volts ±0.1 volt. Fasten the side panels securely to the module.

See Page B-(3)

b. Incremental Tuning Oscillator Tracking

(1) Rotate the Incremental Tuning capacitor over its range and check that the Lock Indicator light stays on. A slight readjustment (CCW) of L1 in the Second Oscillator may be necessary if the light stays out at any point.

(2) Set the Cursor index to midrange.

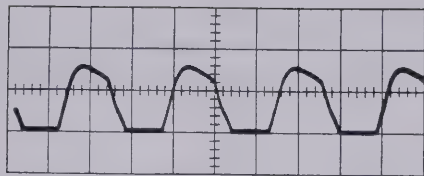
(3) Set the Incremental Tuning dial to 100 kc and check that the tuning capacitor is 11/32" from full mesh.

(4) Set Attenuator switch to 0 db.

(5) Using the Frequency Counter, set the Signal Generator to 1 mc ±10 cps. Set level to 0 db. Connect Signal Generator to INPUT of voltmeter.

(6) Set voltmeter Bandwidth switch to 250 ~.

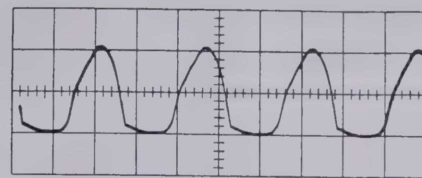
(7) Set Main Tuning to 1 mc, locked condition.



Vert: 20 V/cm

Hor: 2 usec/cm

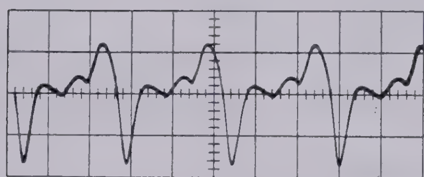
a. Phase Discriminator, terminal 3 of transformer T1. Incremental Tuning Oscillator capacitor plates meshed.



Vert: 20 V/cm

Hor: 2 usec/cm

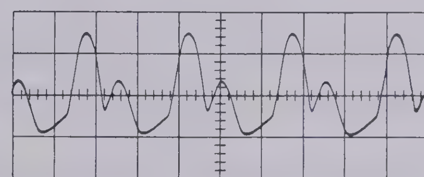
b. Phase Discriminator, terminal 5 of transformer T1. Incremental Tuning Oscillator capacitor plates meshed.



Vert: 5 V/cm

Hor: 2 usec/cm

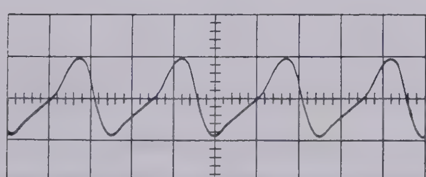
c. Phase Discriminator, terminal 3 of transformer T2. Incremental Tuning Oscillator capacitor plates meshed.



Vert: 5 V/cm

Hor: 2 usec/cm

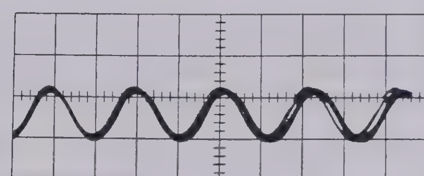
d. Phase Discriminator, terminal 5 of transformer T2. Incremental Tuning Oscillator capacitor plates meshed.



Vert: 2 V/cm

Hor: 2 usec/cm

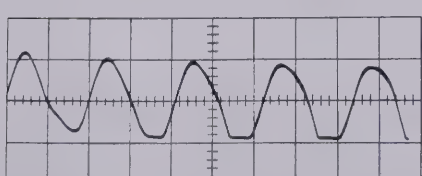
e. Phase Discriminator output, junction of CR1 and R6. Incremental Tuning Oscillator capacitor plates meshed.



Vert: 5 V/cm

Hor: 10 usec/cm

f. 125 KC Low-Pass Filter output, junction of C10, C11, C12. Unlocked waveform.



Vert: 2 V/cm

Hor: 10 usec/cm

g. Incremental Lock Indicator, junction of R5 and R7. Unlocked waveform.

Figure 4-8. Incremental Tuning Module, Waveforms II

(8) Set Incremental Tuning dial to 0.0 kc.

(9) Connect the AC VTVM to the Incremental Tracking Signal Input jack, J3. Connect the Frequency Counter to the AC VTVM output and adjust Range switch of VTVM until Frequency Counter operates properly.

(10) Adjust C6 in the Incremental Tuning Oscillator until the Frequency Counter reads 300 kc ±2 cps.

(11) Adjust L2 in the Incremental Reference Oscillator for maximum reading of the panel meter.

(12) Check that the end frequencies are within ±20 cps of 300 kc (0 kc on dial) and 200 kc (100 kc on dial). Readjust C6 and L1 in the Incremental Tuning oscillator for correct readings if necessary. (Adjust L1 at 200 kc and C6 at 300 kc.)

(13) Starting at the 300 kc end, check the dial settings in 10 kc steps. The 300 kc and 200 kc readings (0 kc and 100 kc dial settings) should be within ±10 cps and all other readings within ±200 cps of each corresponding dial setting. Each setting should be rocked into place with back and forward movements of the tuning knob to eliminate any backlash irregularities. Record readings.

(14) Note the tuning dial settings at all frequency points. If all frequencies read either high or low on the dial shift the capacitor, by loosening its set screws, to achieve an even reading distribution. Tighten set screws after dial scale is properly set. (This adjustment should only be necessary in case an adjustment was required in paragraph (3). Recheck and readjust as necessary the settings of paragraphs (12) and (13).

(15) Adjust incorrect readings by slightly bending the tuning capacitor outside plates. Access to the plates is through the top hole of the Incremental Tuning Module casting. Check end points, paragraph (12) after every adjustment. Recheck dial settings, paragraph (13), after adjustments are complete.

(16) Set the Incremental Tuning dial to read 300 kc ±10 cps on the counter (0 kc dial setting). Disconnect the Frequency Counter from the AC VTVM and connect to the Signal Generator. Check that Signal Generator is still tuned to 1 mc ±10 cps. (Main Tuning dial remains at 1.0 mc, locked condition.) Adjust L2 in the Incremental Reference oscillator for maximum deflection on the voltmeter panel meter.

(17) Repeat the procedure of paragraph 12.a. (6). Make sure that no ac appears on trace over the whole range. Make sure DC voltage is at the zero volts reference line in the -10 kc dial position. Readjust L1 in the Second Oscillator if necessary.

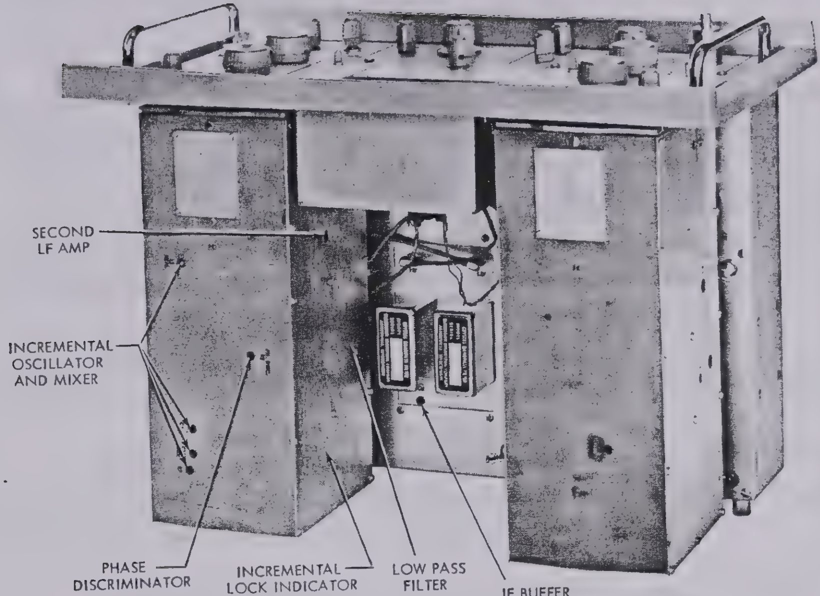


Figure 4-9. Top View, Module Location

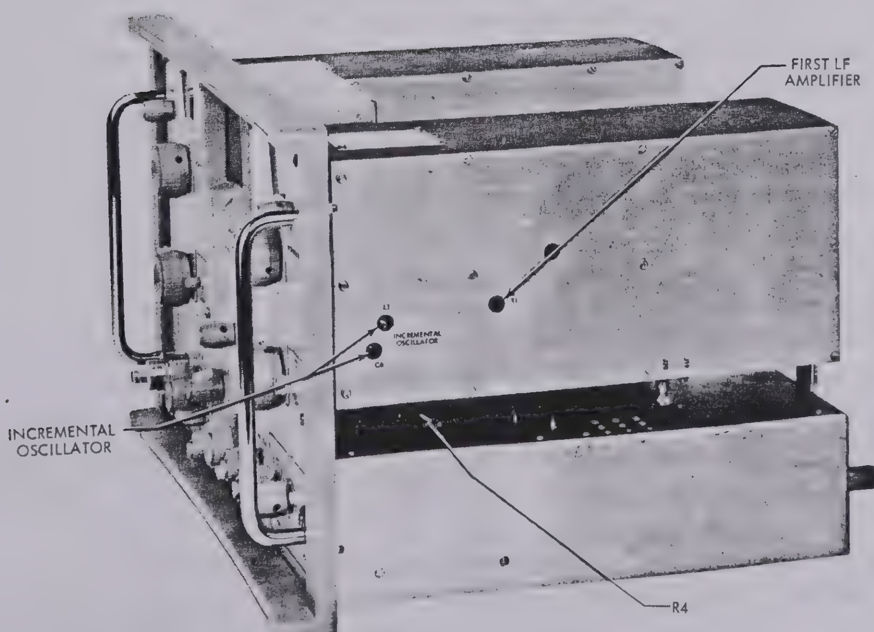


Figure 4-10. Right Side View, Module Location

13. Attenuator Calibration

a. Connect the Signal Generator to the VHF Attenuator and connect the AC VTVM to the Signal Generator output. Connect the VHF Attenuator to the voltmeter and terminate the voltmeter input with a 50 ohm coaxial termination load.

b. Switch the VHF Attenuator to the 100 db position. Set the Siganl Generator to 1 mc and adjust the output to read 0.866 volts on the AC VTVM. Set the voltmeter Attenuator to -90 db, 75 ohm/BRG and the bandwidth switch to 250 ~.

c. Tune the voltmeter to 1 mc and adjust the CAL control to midrange. Set R19 in the Output Amplifier for a voltmeter panel meter reading of 0 db.

d. Switch the voltmeter Attenuator to -80 db, the VHF Attenuator to the 90 db position and check that the panel meter again reads 0 db. If it does not, readjust R4 in the Output Amplifier for a 0 db reading.

e. Switch the impedance switch to 135 ohm/BRG. Check that the meter reading drops 2.56 db from the 0 db mark. Adjust C29 in the attenuator if necessary for an exact -2.56 db reading.

f. Switch the impedance switch to 600 ohm/BRG. Check that the meter reading drops 9.04 from the 0 db mark. Adjust C31 in the Attenuator if necessary for an exact -9.04 db reading.

g. Switch the Attenuator to 0 db and the VHF Attenuator to the 10 db position. Set the impedance switch to 135 ohm/BRG. Adjust the 0 db Attenuator trimmer for an exact -2.56 db meter reading. (Access to the Attenuator trimmer capacitors is obtained by removing the cover plate under the Attenuator knob. The plate is held by two screws which are accessible when the Attenuator knob is removed. Each trimmer is located under the corresponding panel db marking.)

h. Switch the impedance switch to 75 ohm/BRG. Adjust C27 in the Attenuator for an exact 0 db reading if necessary.

i. Switch VHF Attenuator to the 20 db position. Meter should read -10 db. Switch VHF Attenuator to the 30 db position. Meter should read -20 db. Record readings. If readings vary more than ±0.2 db at -10 db and more than ±1.0 db at -20 db the CAL Range adjustment may be set near the end of its range. Recheck paragraph c. above. Both CAL Range adjustment and CAL control should be set close to the mid range position for best meter linearity.

j. Switch the voltmeter Attenuator to CAL and tune for a maximum meter indication of the internal 1 mc calibration signal, then adjust L1 in the Gain Reference oscillator for maximum meter indication.

k. Adjust C23 in the Gain Reference oscillator for an exact 0 db reading.

l. Switch the VHF Attenuator to the 80 db position and the voltmeter Attenuator to -70 db. Adjust the -70 db Attenuator trimmer for a 0 db panel meter reading.

m. Proceed in like manner for the rest of the Attenuator steps, simultaneously decreasing the voltmeter Attenuator and the VHF Attenuator positions by 10 db and adjust each Attenuator trimmer for a 0 db meter reading. The +20 db and +30 db adjustments can be made at the -10 and -20 db meter marks. Check the frequency tuning of the voltmeter after each change in the attenuator setting.

14. 110 KC Bandpass First IF

a. Connect the Signal Generator to the voltmeter input, tune to 1 mc and monitor the input with the AC VTVM. Set the voltmeter CAL control for an exact 0 db meter reading.

b. Shift the frequency of the Signal Generator over the range of the Incremental Tuning oscillator from -10 kc to 100 kc by tuning the Incremental Tuning oscillator and the Signal Generator. Maintain the input level constant.

c. Record the meter deviation at every 10 kc step. Limit: ±0.1 db.

d. If the limit is exceeded, recheck that L5, L6 and L7 in the First IF are correctly peaked (paragraph 7) and tune L7 to compensate for end point discrepancies. Tighten lock nuts on L5, L6, and L7.

15. General Checks

a. Disconnect all equipment from voltmeter input. Switch the voltmeter Attenuator to 0 db, 600 ohm/TERM and the Bandwidth switch to 250 ~. Set the Main Tuning dial to 0.0 mc and the Incremental Tuning dial to 10 kc. Residual meter reading must be below -15 db. Replace Q1 (2N706B) in the Preamplifier if the limit is exceeded.

b. Connect the Signal Generator, terminated with 50 ohms, to the voltmeter input. Set the voltmeter to 75 ohm/BRG. Check the frequency response at 100 kc, 1 mc, 10 mc and 15 mc. Frequency response must be flat within ±0.2 db from 100 kc to 10 mc and ±0.5 db to 15 mc. Adjust C8 in the Preamplifier for the 15 mc response. Replace Q1 in the Preamplifier if the limits are exceeded and recheck paragraph a.